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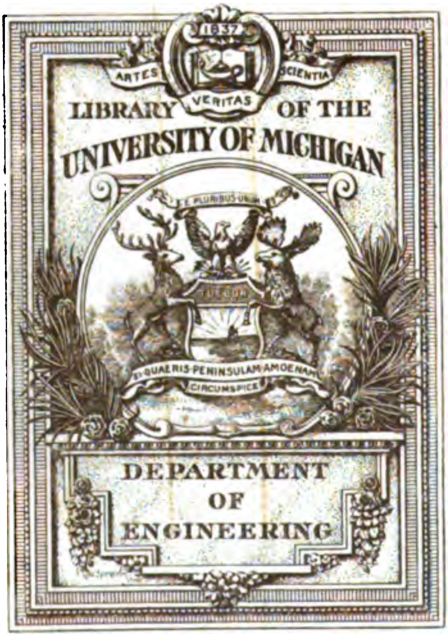

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Institution of municipal & county engineers, Lond.

PROCEEDINGS

OF THE

INCORPORATED ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS

VOLUME XXXI. 1904-1905

EDITED BY

THOMAS COLE

ASSOC. M. INST. C.E.

(*Secretary of the Association*)

The Association is not as a body responsible for the facts and opinions advanced herein.

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LIST OF OFFICERS, 1905–1906.

COUNCIL.

President.—A. E. COLLINS, M. Inst. C.E., City Engineer, Norwich.

Vice-Presidents.

J. PATTEN BARBER, M. Inst. C.E., Borough Engineer, Islington.
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C. F. WIKE, M. Inst. C.E., City Surveyor, Sheffield.

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W. N. BLAIR, M. Inst. C.E., Borough Surveyor, St. Pancras.
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J. PATON, Borough Engineer, Plymouth.
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S. S. PLATT, M. Inst. C.E., Borough Surveyor, Rochdale.
R. READ, Assoc. M. Inst. C.E., City Surveyor, Gloucester.
H. T. WAKELAM, M. Inst. C.E., County Engineer, Middlesex.
A. E. WHITE, M. Inst. C.E., City Engineer, Hull.

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W. WEAVER, M. Inst. C.E., Borough Engineer, Kensington.
A. T. DAVIS, M. Inst. C.E., County Surveyor, Salop.

Elective Past Presidents.

O. C. ROBSON, M. Inst. C.E., Surveyor, Urban District Council, Willesden, N.W
W. HARPUR, M. Inst. C.E., Borough Engineer, Cardiff.
J. LOBLEY, M. Inst. C.E., Borough Engineer, Hanley.

Honorary District Secretaries.

African District.—J. COOK, Assoc. M. Inst. C.E., Capetown.
Eastern District.—J. W. COCKRILL, M. Inst. C.E., Great Yarmouth.
Home District.—R. J. THOMAS, M. Inst. C.E., Aylesbury.
Indian District.—J. HALL, M. Inst. C.E., Bombay.
Irish District.—R. H. DORMAN, M. Inst. C.E., Armagh.
Lancashire and Cheshire District.—C. BROWNRIDGE, M. Inst. C.E., Birkenhead.
Metropolitan District.—J. R. DIXON, Assoc. M. Inst. C.E., Woolwich.
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Northern District.—J. P. DALTON, Ryton-on-Tyne.
Scottish District.—J. BRYCE, Assoc. M. Inst. C.E., Partick, N.B.
Wales (North).—
„ (South).—W. E. C. THOMAS, Assoc. M. Inst. C.E., Neath.
Western District.—J. S. PICKERING, M. Inst. C.E., Cheltenham.
Yorkshire District.—W. H. HOPKINSON, Assoc. M. Inst. C.E., Keighley.

General Hon. Secretary.

CHAS. JONES, M. Inst. C.E.

Honorary Treasurer.

LEWIS ANGELL, M. Inst. C.E.

Secretary.

THOMAS COLE, Assoc. M. Inst. C.E., 11 Victoria Street, London, S.W.

Telegraphic Address:
"Bisecting, London."

Telephone Number:
"5083 Westminster."

PAST PRESIDENTS.

1873–4 }
1874–5 } LEWIS ANGELL, M. Inst. C.E.
1875–6. *J. G. LYNDE, M. Inst. C.E.
1876–7. JAMES LEMON, M. Inst. C.E.
1877–8. *F. ASHMEAD, M. Inst. C.E.
1878–9. G. F. DEACON, LL.D., M. Inst. C.E.
1879–80. *E. PRITCHARD, M. Inst. C.E.
1880–1. *A. W. MORANT, M. Inst. C.E.
1881–2. *W. S. TILL, M. Inst. C.E.
1882–3. C. JONES, M. Inst. C.E.
1883–4. W. H. WHITE, M. Inst. C.E.
1884–5. *W. G. LAWS, M. Inst. C.E.
1885–6. *R. VAWSER, M. Inst. C.E.
1886–7. J. LOBLEY, M. Inst. C.E.
1887–8. *J. GORDON, M. Inst. C.E.
1888–9. E. B. ELLICE-CLARK, M. Inst. C.E.
1889–90 }
1890–91 } H. P. BOULNOIS, M. Inst. C.E.
1891–2. T. DE C. MEADE, M. Inst. C.E.
1892–3. J. CARTWRIGHT, M. Inst. C.E.
1893–4. J. T. EAYRS, M. Inst. C.E.
1894–5. A. M. FOWLER, M. Inst. C.E.
1895–6. *E. R. S. ESCOTT, M. Inst. C.E.
1896–7. F. J. C. MAY, M. Inst. C.E.
1897–8. Sir ALEX. R. BINNIE, M. Inst. C.E.
1898–9. O. C. ROBSON, M. Inst. C.E.
1899–1900. W. HARPUR, M. Inst. C.E.
1900–01. *C. H. LOWE, M. Inst. C.E.
1901–02. E. GEORGE MAWBEY, M. Inst. C.E.
1902–03. T. H. YABBICOM, M. Inst. C.E.
1903–04. W. WEAVER, M. Inst. C.E.
1904–05. A. T. DAVIS, M. Inst. C.E.

* Deceased.

LIST OF MEMBERS.

It is particularly requested that every Change of Address may be communicated without delay to the Secretary.

* *Those Members against whose names a star is placed have obtained the Certificate of the Association.*

R *signifies re-election under By-law 5a.* G *elected as Graduate.* A *elected as Associate.* TA *transferred to Associate class.* T *transferred to Member.*

P *Signifies recipient of Association's* £10 *premium.*

P „ „ „ £5 *premium.*

HONORARY MEMBERS.

Date of Election and Transfer.		
1897 Oct. 16	**BECHMANN, G.**	Ingénieur en chef des Ponts et Chaussées, Paris.
1898 Dec. 17	**BICKNELL, R. H., M. Inst. C.E.**	Local Government Board, Whitehall, S.W.
1888 Mar. 3	**CODRINGTON, THOS., M. Inst. C.E.**	5 Riverdale Rd., Twickenham Park.
1904 Feb. 27	**COWAN, P. C., M.Inst.C.E.**	Chief Engineering Inspector, Local Government Board, Ireland.
1901 Mar. 23	**HASSELT, J. VAN**	Director of Public Works, Amsterdam.
1905 Sept. 23	**HAWKSLEY, CHARLES, M. Inst. C.E.**	30 Great George Street, S.W.
1892 Apr. 23	**PUTZEYS, E.**	Ingénieur en chef, Directeur de la Ville de Bruxelles.
1890 Sept. 13	**ROBINSON, HY., M. Inst. C.E.**	Parliament Mansions, Westminster, S.W.
1874 June 1	**TULLOCH, Major H., C.B., R.E.**	28 Victoria Street, S.W.
1904 Jan. 23	**WILLCOCKS, G. W., M. Inst. C.E.**	Chief Engineering Inspector, Local Government Board, Whitehall, S.W.

MEMBERS.

1893 Oct. 21	**Abrahams, C. V.**	City Surveyor, Kingston, Jamaica.
1894 June 21 R1902 Mar. 22	**Aburrow, C., M. Inst. C.E.**	31/32 Bettelheim Buildings, Johannesburg, S.A.
1903 May 16	**Adams, A. E.**	Borough Engineer, Chippenham, Wilts.
1896 Jan. 18	**Aitken, T., M. Inst. C.E.**	County Surveyor, Cupar, Fife.
1897 Jan. 16	**Allen, A. T.**	Surveyor to the Urban District Council, Portslade-by-Sea, Sussex.
1873 May 2 R1884 Jan. 26	***Allen, T. T.**	Broad Street, Stratford-on-Avon.

Date of Election and Transfer.		
1897 June 19	Alves, G.	Surveyor to the Urban District Council, Glastonbury.
1890 June 26	Anderson, R. S., Assoc. M. Inst. C.E.	County Surveyor, Peebles, N.B.
1900 Dec. 15	Anderson, W. V., Assoc. M. Inst. C.E.	City Surveyor, Winchester.
G1898 June 30 T1899 Oct. 21	*Andrews, S. P.	Borough Surveyor, Faversham.
G1894 Oct. 20 T1899 Oct. 21	*Angel, R. J., A. M. Inst. C.E.	Borough Surveyor, Bermondsey, S.E.
1894 May 19	*Angell, J. A., A.M.Inst.C.E.	Surveyor to the Urban District Council, Beckenham, S.E.
1873 Feb. 15	**ANGELL, LEWIS, M. Inst. C.E.** (*Past President, and Hon. Treasurer. Member of Council.*)	"Calside," Carlisle Road, Eastbourne.
1899 June 29	Anstee, J.	Surveyor to the Rural District Council, Guildford.
1880 May 27 R1899 Feb. 25	Armistead, R., Assoc. M. Inst. C.E.	8 Charles Street, Bradford.
1900 June 16	Asquith, A.	Surveyor to the Urban District Council, Holyhead.
1890 June 26	Atkinson, J., A.M. Inst. C.E.	Borough Surveyor, Stockport.
1904 Aug. 4	Atkinson, T. B.	County Surveyor, Earlston, Berwickshire, N.B.
1897 Feb. 13 R1905 Sept. 23	Baff, C. J.	Council Chambers, Gosforth, Newcastle-on-Tyne.
1904 Jan. 23	Baines, C. O.	Surveyor to the Urban District Council, Paignton.
1900 Feb. 10	Bains, G.	Surveyor to the Urban District Council, Saltburn-by-the-Sea.
1884 May 29	Baker, F.	Borough Surveyor, Middlesbrough, Yorks.
1891 Aug. 1 R1903 Feb. 21	Baker, J., A.M. Inst. C.E.	75 High Street, Slough.
1896 June 25	Baldwin, L. L., A.M. Inst. C.E.	Surveyor to the Urban District Council, Coalville, Leicester.
G1891 Aug. 1 T1896 Feb. 22	*Ball, B., A.M. Inst. C.E.	Borough Surveyor, Nelson, Lancs.
G1887 Sept. 17 T1898 Feb. 19	*Ball, G., A.M. Inst. C.E.	Surveyor to the Urban District Council, Bexhill.
1879 Oct. 28	Banks, W., A.M. Inst. C.E.	City Surveyor, Rochester.
1905 Apr. 29	Barber, E. H., A.M.Inst.C.E.	Town Surveyor, Goole.
1887 Mar. 12	Barber, J. Patten, M. Inst. C.E. (*Vice-President.*)	Borough Engineer, Islington, N.
1903 June 25	Barclay, J.	Surveyor to the Urban District Council, Chiswick.
G1888 Sept. 15 T1892 July 11	*Barnes, S. W. J., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Hanwell.
1897 Jan. 16	Barrett, E. J., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Staines.
1899 Jan. 21	Barrs, J. D.	Surveyor to the Urban District Council, Bromyard.
1898 Jan. 15	Barton, J. I.	Surveyor to the Urban District Council, St. Helens, Isle of Wight.

Date of Election and Transfer.		
G1903 Jan. 17 T1905 May 27	*Bate, E. M.	Surveyor to the Urban District Council, Frinton-on-Sea.
1896 Oct. 24 R1904 May 28	Baylis, T. P., Assoc. M. Inst. C.E.	Surveyor, Droitwich.
G1901 June 8 T1903 July 25	*Beacham, W. E.	Town Surveyor, Leek.
1903 May 16	Bean, J. A.	County Surveyor, Northumberland. Moot Hall, Newcastle.
1894 Jan. 13	Beaumont, A.	County Surveyor, Yorks, East Riding. County Hall, Beverley.
1897 Mar. 13	Beaumont, G. E.	Surveyor to the Rural District Council, Wortley. "Holme Lea," Greenoside, near Sheffield.
1897 Mar. 13	Beaumont, T. C.	Surveyor to the Rural District Council, Driffield.
1892 Jan. 16	Bell, G., Assoc. M. Inst. C.E.	Borough Surveyor, Swansea.
1897 Jan. 16	Bell, G. J., M.Inst.C.E.	County Surveyor, Cumberland. Carlisle.
1895 Jan. 19	Bellingham, A. W. H., M. Inst. C.E.	Engineer-in-Chief, British Municipality, Tientsin, North China.
1896 Jan. 18	Bennett, H. M.	Surveyor to the Rural District Council, Keynsham, Bristol.
1886 Dec. 18 R1902 Nov. 8	Bennett, W. B. G., Assoc. M. Inst. C.E.	Midland Bank Chambers, Southampton.
G1898 Dec. 17 T1900 July 19	*Bennetts, J. P.	Surveyor to the Urban District Council, Harrow.
1886 Oct. 16 R1896 Jan. 18	Berrington, R. E. W., M. Inst. C.E.	Graisley, Wolverhampton.
1892 Mar. 11 R1899 May 6	Beswick, W. H., Assoc. M. Inst. C.E.	214 Astley Street, Dukinfield, Cheshire.
1891 June 6	Bettany, F.	Borough Engineer, Burslem.
1902 Mar. 22	Bibbey, T.	Surveyor to the Urban District Council, Audley, Staffs.
1890 Mar. 29	BINNIE, SIR A. R., M. Inst. C.E. (*Past President.*)	9 Gt. George Street, Westminster, S.W.
1896 Nov. 28	Bird, W. F.	Surveyor to the Urban District Council, Midsomer Norton.
1897 Jan. 16	Birks, E.	Highway Surveyor to Rural District Council, Uxbridge.
1901 Feb. 16	Blackburn, J.	Surveyor to the Urban District Council, Soothill Upper.
P1873 May 2	Blackshaw, W., Assoc. M. Inst. C.E.	Borough Surveyor, Stafford.
1904 Aug. 5	Blackwood, R.	Borough Surveyor, Kilmarnock, N.B.
1886 June 12	Blair, W. N., M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, St. Pancras.
1903 Oct. 17	Bland, J. D.	Surveyor to the Urban District Council, Chesterton.
1900 Mar. 10	Blood, A. T.	Surveyor to the Urban District Council, Hitchin.
1902 Nov. 8	Borg, E. A.	Borough Surveyor, Margate.
1895 Jan. 19 R1903 Feb. 21	Botterill, C., A.M.Inst.C.E.	583 Fulham Road, Walham Green, S.W.

Date of Election and Transfer.		
1904 Feb. 27	**Bottomley, H.**	Surveyor to the Urban District Council, Bingley.
1877 May 1	**BOULNOIS, H. P., M. Inst. C.E.** (*Past President.*)	Local Government Board, Whitehall, S.W.
1903 Dec. 12	**Bourne, J.**	Surveyor to the Urban District Council, Rawmarsh.
G1898 June 30 TA1901 Dec. 7 T1903 Mar. 21	***Bowe, D. J.**	Surveyor, Eastbourne.
1898 Mar. 19 R1903 Feb. 21	**Bowen, H. W.**	Rose Villa, Hayward's Heath.
1904 Aug. 12	**Bowie, J. McL.**	Burgh Surveyor, Maxwelltown, Dumfries, N.B.
1898 Feb. 19	**Bowles, A. R., Assoc. M. Inst. C.E.**	Surveyor to the Urban District Council, Sandgate.
1898 Oct. 15	**Boyle, J. C., A. M. Inst. C.E.**	City Surveyor, Armagh.
1903 May 16	**Bradley, A.W., A.M.Inst.C.E.**	Borough Engineer, Bury, Lancs.
G1889 May 18 T1893 Apr. 22	***Bradley, J. W., M. Inst. C.E.** (*Member of Council.*)	City Engineer, Westminster, S.W.
1897 Jan. 16	**Bradley, W. L.**	Surveyor to the Urban District Council, Tonbridge.
G1894 Jan. 13 T1896 Oct. 24	***Bradshaw, F. E. G.**	Borough Surveyor, Tamworth.
1873 May 2	**Bressey, J. T.**	Surveyor to the Urban District Council, Wanstead, Essex.
1891 Aug. 1	**Brett, J. H.**	County Surveyor, Co. Antrim. Belfast, Ireland.
1891 Aug. 1	**Brettell, W. H.**	Surveyor to the Urban District Council, Rowley Regis, Staffordshire.
1894 Oct. 20	**Bridges, O. A.**	Surveyor to the Urban District Council, Bognor.
1891 Mar. 21	**Brierley, J. H., A. M. Inst. C.E.**	Borough Surveyor, Richmond, Surrey.
1901 Dec. 7	**Brodie, J. A., M. Inst. C.E.** (*Member of Council.*)	City Engineer, Liverpool.
1889 Apr. 13	**Brodie, J. S., A.M. Inst. C.E.**	Borough Engineer, Blackpool.
1905 May 27	**Brooke, A.**	Surveyor to the Rural District Council, Sleaford.
1894 Oct. 20	**Brooke, J.**	Surveyor to the Urban District Council, Northwich, Cheshire.
1885 Feb. 7 R1892 Apr. 23	**Brooke, W., Assoc. M. Inst. C.E.**	Surveyor to the Rural District Council, Strood. "Lympstone," Goddington Road, Rochester.
1891 Feb. 21	**Broom, G. J. C., M.Inst. C.E.**	Borough Engineer, St. Helen's, Lancashire.
1884 July 10	**Brown, A., M. Inst. C.E.**	Borough Engineer, Nottingham.
1898 Jan. 15	**Brown, C., A. M. Inst. C.E.**	Borough Engineer, Chelmsford.
1904 Aug. 25	**Brown, Chas.**	Burgh Surveyor, Hawick, N.B.
1905 Jan. 28	**Brown, F.**	Town Engineer, Kroonstad, O.R.C., South Africa.
1905 Sep. 23	**Brown, H. Lane, A. M. Inst. C.E.**	Supervising Engineer, Lucknow, United Provinces, India.
1881 June 18 R1904 Jan. 23	**Brown, J. W., M. Inst. C.E.**	Church Square, West Hartlepool.
G1894 July 7 T1898 Sept. 3	***Brown, R., A.M. Inst. C.E.**	Surveyor to the Urban District Council, Southall Norwood.

Date of Election and Transfer.		
1889 Feb. 9 R1898 Jan. 15	*Brown, R. R.	Electrical Engineer to the Urban District Council, Bridlington.
1893 Mar. 4	*Brownridge, C., M. Inst.C.E. (*Member of Council.*)	Borough Engineer, Birkenhead. *Hon. Secretary*, Lancashire and Cheshire District.
1904 Aug. 9	Bruce, J. S.	Burgh Surveyor, Drumlisden, Kirriemuir, N.B.
1901 Feb. 16	Bryce, J., A.M. Inst. C.E. (*Member of Council*).	Burgh Surveyor, Partick, N.B., *Hon. Sec.* Scottish District.
G1889 Feb. 9 T1902 Mar. 22	*Bryning, W. G.	County Surveyor, Northallerton, Yorks.
1873 May 2	Buckham, E., M. Inst. C.E.	Borough Surveyor, Ipswich.
1897 July 8 R1902 Mar. 22	Buckley, M. J., Assoc. M. Inst. C.E.	26 Bessborough Terrace, N.C.R., Dublin.
1897 Feb. 13	Bull, H. F., A.M. Inst. C.E.	County Surveyor, Cheshire.
1895 Feb. 16	Bunting, T. F.	Borough Surveyor, Maidstone.
1895 Jan. 19	Burden, A. M., Assoc. M. Inst. C.E.	County Surveyor, Kilkenny.
1892 Sept. 24	Burgess, S. E., M. Inst. C.E.	Borough Engineer, South Shields.
1900 Apr. 21	Burkitt, J. P., A.M.Inst.C.E.	County Surveyor, Enniskillen.
1905 Mar. 3	Burn, W., A. M. Inst. C.E.	Surveyor to the Urban District Council, Sutton-in-Ashfield, Notts.
1904 Aug. 6	Burns, D.	Burgh Surveyor, Pollokshaws, N.B.
1890 June 7	Burslam, R.	Borough Surveyor, Congleton.
G1895 Jan. 19 T1902 Jan. 25	*Burton, A., A.M. Inst. C.E.	Borough Engineer, Stoke-on-Trent.
1897 Jan. 16	Busbridge, T. A.	Surveyor to the Rural District Council, Spilsby.
G1899 June 29 TA1902 Jan. 25 T1904 Feb. 27	*Bush, W. E., A.M. Inst. C.E.	Borough Engineer, Sudbury, Suffolk.
1890 Sept. 13	Butler, W.	Surveyor to the Urban District Council, Fareham.
1899 June 29	Butterworth, A. S., Assoc. M. Inst. C. E.	Municipal Engineer, Port Elizabeth, S. Africa.
1894 Apr. 6	Caink, T., Assoc.M.Inst.C.E.	City Engineer, Worcester.
1891 Dec. 12 R1903 Jan. 17	Cairncross, T. W., Assoc. M. Inst. C.E.	13 Duncan's Chambers, Shortmarket Street, Cape Town, S. Africa.
1903 Jan. 17	Calder, W., A. M. Inst. C.E.	City Engineer, Prahran, Victoria.
1891 Oct. 17	Campbell, A. H., M. Inst. C.E.	Engineer and Surveyor, Town Hall, East Ham, E.
1887 Mar. 12	Campbell, K. F., M. Inst. C.E.	Borough Engineer, Huddersfield.
1888 May 12	Capon, E. R.	Surveyor to the Urban District Council, Epsom.
1890 Oct. 18 R1899 Jan. 21	Card, H.	North Street, Lewes.
1891 June 25 R1902 Feb. 22	Carline, J., A. M. Inst. C.E.	"Merivale," Catford Hill, S.E.

Date of Election and Transfer.		
1903 Feb. 21	Carter, A. H.	Surveyor to the Urban District Council, Litherland, Liverpool.
1901 June 27	Carter, G. E.	Surveyor to the Rural District Council, Winchester.
1897 June 19	Carter, G. F.	Surveyor to the Urban District Council, Mexborough.
G1892 July 11 TA1901 Dec. 7 T1904 Jan. 23	*Carter, G. F., A.M.Inst.C.E.	Borough Engineer, Croydon.
1898 Dec. 17	Cartwright, A. S.	Surveyor to the Urban District Council, Wilmslow, Cheshire.
1873 May 2	CARTWRIGHT, J., M. Inst. C.E. (*Past President.*)	Peel Chambers, Market Place, Bury.
1904 June 26	Carver, W.	Surveyor to the Rural District Council, Melford. 3 Melford Road, Sudbury, Suffolk.
1895 Mar. 16	Cass, R. W.	Surveyor to the Urban District Council, Farnham, Surrey.
1895 Mar. 16 R1899 Feb. 25	Catt, A. J.	"Laurel Dene," Kingston-by-Sea, near Brighton.
1896 Mar. 21	Chadwick, J.	Surveyor to the Urban District Council, Fenny Stratford.
1903 Jan. 17	Chambers, S. H.	Surveyor to the Urban District Council, Hampton.
1901 Dec. 7	Chancellor, W. B.	Surveyor to the Urban District Council, Brownhills, Staffs.
1897 Jan. 16	Chapman, C. R. W.	Surveyor to the Urban District Council, Wembley.
1893 Mar. 4 R1899 May 6	Charles, T.	Bessborough Road, Harrow.
1884 Dec. 20	Chart, R. M.	Surveyor to the Rural District Council, Croydon. Town Hall, Croydon.
1900 Feb. 10	Chowins, W. H.	Surveyor to the Urban District Council, Burnham, Somerset.
1884 Oct. 9	Clark, J., A.M. Inst. C.E.	Surveyor to the Urban District Council, Sleaford.
1898 Sept. 3	Clark, E. O'N.	County Surveyor, Leitrim.
A1902 May 10 T1904 Apr. 30	Clarke, G. E.	Borough Surveyor, Boston, Lincolnshire.
1899 Oct. 21	Clarke, H. A.	Surveyor to the Urban District Council, Briton Ferry.
1898 Oct. 15	Clarry, W. H., A. M. Inst. C.E.	Borough Surveyor, Sutton Coldfield.
1886 Dec. 18	Clarson, H. J.	Surveyor to the Rural District Council, Tamworth.
1901 May 11	Clayton, F. T.	Borough Engineer, Reigate.
1893 July 31	Clough, W.	Surveyor to the Urban District Council, Audenshaw.
1899 Oct. 21	Clucas, R. H.	Borough Surveyor, Kendal.
G1894 July 7 T1896 Oct. 24	*Coales, H. F.	Surveyor to the Urban District Council, Sunbury-on-Thames.
G1886 Oct. 16 T1888 July 12	*Coales, H. G., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Market Harborough.
1882 Sept. 30	Cockrill, J. W., M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Great Yarmouth; *Hon. Secretary*, Eastern District.
1893 June 24	Cockrill, T., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Biggleswade, Beds.

Date of Election and Transfer.		
1904 June 26	Coleby, H. J.	Surveyor to the Rural District Council, Atherstone, Warwickshire.
1892 Sept. 24	Collen, W. M.A., M.Inst.C.E.	County Surveyor, Dublin. 9 Hume Street, Dublin.
1897 July 31	Collingwood, T. A.	Surveyor to the Urban District Council, Itchen, Woolston, Southampton.
1888 May 12	COLLINS, A. E., M. Inst. C.E. (*President.*)	City Engineer, Norwich.
1900 Oct. 15 R1901 June 27	Collins, G. M.	103 Clarendon Road, Whalley Range, Manchester.
1896 Jan. 18	Collins, R.	Surveyor to the Urban District Council, Enfield, N.
1905 Apr. 29	Collins, W. A.	Surveyor to the Rural District Council, Bridgwater.
1886 May 1 R1897 Feb. 13	Comber, P. F., M. Inst. C.E.	19 Lower Leeson Street, Dublin.
G1897 July 31 T1900 Dec. 15	*Cook, F. C.	Surveyor to the Urban District Council, Nuneaton.
1893 Apr. 22	Cook, F. P., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Mansfield Woodhouse.
G1888 July 12 T1890 Mar. 29	*Cook, J., Assoc. M. Inst. C.E. (*Member of Council.*)	Borough Engineer, Cape Town, S. Africa. *Hon. Sec.* African District.
G1888 July 12 T1890 Mar. 29	*Cooper, C. H., M. Inst. C.E. (*Member of Council.*)	Borough Engineer, Wimbledon.
1898 Sept. 3	Cooper, E. C.	Surveyor to the Urban District Council, Shanklin, Isle of Wight.
1894 Oct. 20	Cooper, F. A., C.M.G., M. Inst. C.E.	Director of Public Works, Colombo, Ceylon.
1887 Sept. 17	Cooper, W. W.	Surveyor to the Urban District Council, Slough.
1893 Apr. 22 R1902 Nov. 8	Copley, C. T., A.M.Inst.C.E.	252 Barkerhouse Road, Nelson, Lancashire.
1896 Nov. 28	Corbett, J.	Borough Engineer, Salford.
1896 Jan. 18	Cordon, R. C.	Surveyor to the Rural District Council, Belper. "Belmont," Duffield, near Derby.
G1896 May 29 T1897 June 19	*Corrie, H. W.	Surveyor to the Urban District Council, Lower Bebington, Cheshire.
1894 June 21 R1903 Jan. 17	Cotterell, A. P. I., M.Inst. C.E.	28 Baldwin Street, Bristol; and 17 Victoria Street, S.W.
1891 June 25 R1897 July 31	Coverley, J. S.	Surveyor, Penmaenmawr.
1898 May 21	Cox, J.	Surveyor to the Urban District Council, Margam, Port Talbot.
P1880 Feb. 7	Cox, J. H., M. Inst. C.E.	City Surveyor, Bradford.
1900 Mar. 10	Crabtree, W., M.Sc., A.M. Inst. C.E.	Highway Surveyor to the Rural District Council, Doncaster.
1887 Dec. 10	Crabtree, W. H. B., M.Inst. C.E.	Borough Surveyor, Doncaster.
P1881 May 6	Creer, A., Assoc. M. Inst. C.E. (*Member of Council.*)	City Surveyor, York.

Date of Election and Transfer.		
1900 July 19	Cross, A. W., A. M. Inst. C.E.	Surveyor to the Urban District Council, King's Norton.
1889 Dec. 14	*Crowther, J. A., Assoc. M. Inst. C.E.	Borough Engineer, Southampton.
G1900 Jan. 19 T1903 May 16	*Crump, E. H.	Surveyor to the Urban District Council, Hinckley.
G1898 June 30 T1904 Apr. 30	*Cudbird, T. O.	Borough Surveyor, Beccles.
1900 June 16	Cumming, W.	Highway Surveyor to the Rural District Council, Lanchester, co. Durham.
1889 Dec. 14	Curball, A. E.	Surveyor to the Rural District Council, Solihull, Warwickshire.
1896 Apr. 25	Curry, W. F.	P.W.D., Pretoria, South Africa.
1893 Mar. 4 R1899 Feb. 25	Curry, W. T., A. M. Inst. C.E.	Ruabon, North Wales.
1897 Feb. 13	Cutler, H. A., A.M.Inst.C.E. (*Member of Council.*)	City Surveyor, Belfast.
1893 June 24	*Dalton, J. P. (*Member of Council.*)	Surveyor to the Urban District Council, Ryton-on-Tyne; *Hon. Secretary*, Northern District.
1899 Jan. 21	Davidson, J. F.	Surveyor to the Urban District Council, Willington Quay.
1900 Oct. 15	Davies, W. J.	Surveyor to the Urban Dristrict Council, Nantyglo and Blaina. Council Offices, Blaina.
1880 Apr. 10	DAVIS, A. T., M. Inst. C.E. (*Past President. Member of Council.*)	County Surveyor, Salop. Shrewsbury.
1900 Oct. 15	*Dawson, C. F.	Surveyor to the Urban District Council, Barking.
1884 Apr. 19 R1902 Nov. 8	Dawson, C. J.	Wykeham House, Barking.
1896 July 25	Dawson, N. H.	Borough Surveyor, Banbury.
1879 May 1	Dawson, W., M. Inst. C.E.	Surveyor to the Urban District Council, Leyton, N.E.
1898 Jan. 15	Day, C.	Borough Surveyor, Chatham.
1873 Dec. 9	DEACON, G. F., LL.D. (Glasgow), M. Inst. C.E. (*Past President.*)	16 Great George Street, Westminster, S.W.
1898 Jan. 15	Deane, J.	Surveyor to the Urban District Council, Smallthorne.
1892 Mar. 11	*Dearden, H., A. M. Inst. C.E.	Borough Engineer, Dewsbury.
1904 July 14	Delany, J. F.	City Engineer, Cork.
P1890 Feb. 1	Dennis, N. F., A.M.Inst.C.E.	Borough Engineer, West Hartlepool.
1880 May 27 R1903 Feb. 21	Dent, W.	Railway Street, Nelson, Lancashire.
1896 July 25	Dewhirst, J.	Surveyor to the Rural District Council, Chelmsford.
1895 June 27	Dickinson, R.	Surveyor to the Urban District Council, Berwick-on-Tweed.
1890 Sept. 13 R1896 Jan. 18	Dickinson, T. R., Assoc. M. Inst. C.E.	Burton House, Clifton, York.

Date of Election and Transfer.		
1900 Feb. 10	DIGGLE, JAMES	Surveyor to the Urban District Council, Matlock.
1881 Dec. 10	DIGGLE, J., A.M. Inst. C.E.	Water Engineer, Heywood.
1889 Sept. 21	DIGGLE, WM.	Surveyor to the Rural District Council, Runcorn. Frodsham, Chester.
1877 Oct. 20	DITCHAM, H.	Borough Surveyor, Harwich.
1897 Apr. 10	DIVER, D. J.	Surveyor to the Urban District Council, Desborough.
1897 Jan. 16 R1903 Jan. 17	DIXON, F. J., A.M. Inst. C.E.	5 Prospect Crescent, Harrogate.
G1891 Aug. 1 T1896 Oct. 24	*DIXON, J. R., A.M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Woolwich. *Hon. Secretary*, Metropolitan District.
1887 June 18	DIXON, R., Assoc.M.Inst.C.E.	Borough Surveyor, Stratford-on-Avon.
1889 July 4	DODD, P., Assoc. M. Inst.C.E.	Borough Surveyor, Western District, Wandsworth, S.W.
1897 Jan. 16	*DODGEON, A.	Surveyor to the Urban District Council, Clayton-le-Moors.
1888 May 12	DORMAN, R. H., M. Inst. C.E. (*Member of Council.*)	County Surveyor, Armagh; *Hon. Secretary*, Irish District.
1898 June 30	DORMER, P. C.	Surveyor to the Urban District Council, Chesham, Bucks.
G1903 June 25 T1904 Sept. 17	*DOUGLAS, S.	Surveyor to the Urban District Council, Kenilworth.
1899 Oct. 21	DRYLAND, A., A. M. Inst. C.E.	County Surveyor, Hereford.
1891 Dec. 12	DUFFIN, W. E. L., M. Inst. C.E. I.	County Surveyor, Waterford, Ireland.
1900 Dec. 15 R1901 June 8	DUNCH, T. H.	27 Clement's Lane, Lombard Street, E.C.
1898 May 21	DUNN, J...	Surveyor to the Rural District Council, Chesterton. Brunswick House, Cambridge.
1873 Feb. 15	DUNSCOMBE, C., M.A., M. Inst. C.E.	92 Victoria Street, Westminster, S.W.
G1891 Jan. 21 T1892 Sept. 24	*DYACK, W., M. Inst. C.E. ..	Burgh Surveyor, Aberdeen.
1882 June 29	DYER, S...	Engineer to the Rural District Council, Bridlington.
1879 May 1	EARNSHAW, J. T., Assoc. M. Inst. C.E.	Borough Surveyor, Ashton-under-Lyne, Lancashire.
1904 Aug. 3	EASTON, W. C., B. Sc., M. Inst. C.E.	Glasgow Main Drainage Works, Partick, N.B.
1900 May 19 R1901 Dec. 7	*EASTWOOD, J.	2 Dunkirk Crescent, Halifax.
1883 Aug. 4	EATON-SHORE, G., Assoc. M. Inst. C.E.	Borough Surveyor, Crewe.
1877 Nov. 18	EAYRS, J. T., M. Inst. C.E. (*Past President.*)	39 Corporation Street, Birmingham.
1890 May 3	EBBETTS, D. J.	Surveyor to the Urban District Council, Acton.
1890 Feb. 1	EDDOWES, W. C.	Borough Surveyor, Shrewsbury.
1891 Jan. 21 R1896 Jan. 18	*EDGE, F. J., M. Inst. C.E. ..	City Engineer, Newcastle-on-Tyne.

Date of Election and Transfer.		
1891 Sept. 12	Edmondson, S.	Surveyor to the Rural District Council, Burnley.
1904 Jan. 23	Edwards, H. C. J., Assoc. M. Inst. C.E.	Borough Engineer, Lambeth.
1898 Apr. 23	Edwards, T. L.	County Surveyor. Glamorgan Bridgend, Glam.
1897 July 31	*Elford, E. J.	Borough Surveyor, Southend-on-Sea.
1885 Oct. 3	Elford, J.	Borough Surveyor, Poole.
1873 Feb. 15	ELLICE-CLARK, E. B., M. Inst. C.E. (*Past President.*)	13 Charles Street, St. James's, London, S.W.
1900 Apr. 21	Elliott, F. T.	Surveyor to the Rural District Council, Isle of Thanet, Birchington-on-Sea.
1895 July 27	Entwisle, H.	Surveyor to the Urban District Council, Swinton, near Manchester.
1897 Jan. 16	Evans, E., A. M. Inst. C.E.	County Surveyor, Carnarvonshire.
1895 Jan. 19	Evans, E. I., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Penarth, S. Wales.
1896 May 29	Evans, J. P.	Surveyor to the Rural District Council, Wrexham.
1903 Oct. 17	Evans, S.	County Surveyor, Mold, Flintshire.

1890 June 7	Fairley, W., A.M. Inst. C.E.	Richmond Main Sewerage Board, Kew Gardens, S.W., and 69 Victoria Street, S.W.
G1898 June 30 T1899 Feb. 25	*Farnham, W. A.	Surveyor to the Urban District Council, Foots Cray. Sidcup.
1887 July 14	Farrall, T.	Surveyor to Urban District Council, Sherborne, Dorset.
1893 July 31	Farrington, T. B., A. M. Inst. C.E.	Surveyor to the Rural District Council, Conway. Trinity Square, Llandudno.
1896 Jan. 18	Farrington, W., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Woodford Green, Essex.
1896 Nov. 28	Feather, F.	Surveyor to the Urban District Council, Cheriton, near Folkestone.
1900 Dec. 15	Fellows, T. E.	Surveyor to the Urban District Council, Willenhall.
1894 Jan. 13	Fenn, T...	Surveyor to the Urban District Council, Belper.
1887 Sept. 17 R1899 June 10	Fiddian, W.	Engineer to Stourbridge and Stour Valley Sewerage Boards. Old Bank Offices, Stourbridge.
P1899 Jan. 21	Fidler, A., A. M. Inst. C.E.	Borough Engineer, Northampton.
G1898 June 30 T1904 Jan. 23	*Finch, E. E., A. M. Inst. C.E.	Borough Engineer, Bethnal Green.
1904 Nov, 18	Findlay, J. R.	Burgh Surveyor, Leith, N.B.
1894 Jan. 13	Findlay, R., A.M. Inst. C.E.	Surveyor, Eltham Green, S.E.
1903 May 16	*Finglah, F. J.	Borough Engineer, Carmarthen.

Date of Election and Transfer.		
G1892 May 28 T1897 Jan. 16 R1903 July 25	*Fitton, G.	Thornfield, Urmston Lane, Stretford, Manchester.
1903 May 16	Fitzmaurice, M., C.M.G., M. Inst. C.E.	Chief Engineer, London County Council, Spring Gardens.
1895 Oct. 19	Fleming, M. J.	Borough Surveyor, Town Hall, Waterford.
1893 Jan. 14 R1899 May 6	Flower, T. J. M., Assoc. M. Inst. C.E.	Scottish Buildings, Baldwin Street, Bristol; and 28 Victoria Street, Westminster, S.W.
G1895 July 27 T1899 Jan. 21	*Forbes, A. H.	Surveyor to the Urban District Council, Saffron Walden.
1896 Nov. 28	Ford, G...	City Surveyor, St. Albans.
1890 Sept. 13 R1905 Jan. 28	Foster, T.	51 State Insurance Buildings, Dale Street, Liverpool.
1900 June 16	Fothergill, J. E.	Surveyor to the Urban District Council, Brentwood.
1873 May 2	**FOWLER, ALFRED M.**, M. Inst. C.E. (*Past President.*)	1 St. Peter's Square, Manchester; and 35 Old Queen Street, Westminster, S.W.
1897 Mar. 13	Fox-Allin, C. J.	Surveyor to the Urban District Council, Smethwick.
G1888 May 12 T1893 Oct. 21 R1898 Jan. 15	*Franks, T.W., Assoc. M. Inst. C.E.	Seveirg Chambers, Lewes.
G1898 June 30 T1902 Nov. 8	*Fraser, B. W.	Surveyor to the Urban District Council, Hoylake, Cheshire.
1895 Oct. 19	Frost, H.	Surveyor to the Urban District Council, Gosport and Alverstoke. Gosport.
1887 June 18 R1898 Jan. 15	Fry, W. H., A.M. Inst. C.E.	9 High Street, Gosport.
1877 Oct. 20	Gamble, S. G., Assoc. M. Inst. C.E.	Metropolitan Fire Brigade, Southwark Bridge Road, S.E.
1885 June 6	Gammage, J.	Borough Surveyor, Dudley.
1891 Dec. 12 R1899 June 10	Garratt, C. T.	Estate Office, Newtown Linford, Leicestershire.
1894 Mar. 3	Garrett, J. H.	County Surveyor, Worcester.
1886 Mar. 13 R1902 Feb. 22	Gaskell, P.	Albert Chambers, Carr Lane, Hull.
1902 Jan. 25	Gent, T. W. B.	Surveyor to the Rural District Council, Leigh.
B 1902 Feb. 22	George-Powell, J.	Surveyor to the Rural District Council, Godstone, Surrey.
1905 Jan. 28	Gettings, C. F.	Surveyor to the Urban District Council, Teignmouth.
1901 Oct. 19	Gibbs, A. G.	Surveyor to the Rural District Council, Midhurst, Sussex.
1900 Mar. 10	Gibson, S.	Surveyor to the Urban District Council, Biddulph.
1889 Dec. 14	Ginn, A. F.	District Surveyor to the Kent County Council, Tonbridge. 70 Quarry Hill, Tonbridge.

Date of Election and Transfer.		
1899 June 10	Gladwell, A.	Highway Surveyor, Rural District Council, Eton. 1 Wrexham Road, Slough, Bucks.
1904 Jan. 23	Gledhill, G.	Surveyor to the Urban District Council, Balby with Hexthorpe.
1893 May 13	*Gloyne, R.M., M. Inst. C.E.	District Engineer, Spring Gardens, S.W.
1895 Jan. 19	Golder, T. C.	Borough Surveyor, Deal.
1904 Feb. 27	Goldsworthy-Crump, T.	Surveyor to the Rural District Council, Taunton. 8 St. George's Terrace, Wilton, Taunton.
1886 June 12	Goodyear, H., Assoc. M.Inst. C.E.	Borough Surveyor, Colchester.
1897 June 19	Gordon, F.	Surveyor to the Rural District Council, Halifax. Clifton, Brighouse.
1899 June 10	Goudie, A. H.	Burgh Engineer, Stirling, N.B.
G1897 June 19 T1901 Dec. 7	*Grant, F. T...	Borough Surveyor, Gravesend.
1905 Sept. 23	Gray, C. C.	Surveyor to the Urban District Council, Hayes.
G1887 Feb. 5 PPT1893 Apr. 22	*Greatorex, A.D., A. M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, West Bromwich.
1895 Mar. 5	Green, A. A.	Borough Surveyor, Brackley.
1899 June 10	Green, G., A.M. Inst. C.E...	Borough Engineer, Wolverhampton.
1901 Feb. 16	Green, J. S.	Borough Engineer, Haslingden.
1897 Mar. 13	Green, W.	Surveyor to the Urban District Council, Castleford.
A1901 Dec. 7 T1903 Dec. 12	Greenshields, N., Assoc. M. Inst. C.E.	Borough Engineer, Bedford.
1890 May 3 R1898 Apr. 23	Greenwell, A., Assoc. M. Inst. C.E.	30 Furnival Street, Holborn, E.C.
1883 May 5 R1891 Dec. 12	Greenwood, A.	39 Calder Street, Todmorden.
1898 Mar. 19	Gregory, T.	Surveyor to the Urban District Council, Newburn-on-Tyne.
1892 Jan. 16	Gregson, G.	Surveyor to the Rural District Council, Durham.
1886 Oct. 16	Gregson, J., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Padiham, near Burnley.
1882 Sept. 30	Grieves, R.	Surveyor to the Urban District Council, Cowpen, Blyth, Northumberland.
1897 June 19	Grieves, W. H.	Surveyor to the Urban District Council, Buxton.
1904 Oct. 29	*Griffiths, H. Ll.,	Borough Surveyor, Brecon.
1886 Sept. 11	Grimley, S. S., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Hendon.
1899 Dec. 16	Grimshaw, F. H., A.M. Inst. C.E.	Surveyor to the Urban District Council, Atherton.
1898 Dec. 17	Guilbert, T. J.	States Surveyor, Guernsey.
1892 Apr. 28	Gunnis, J. W.	County Surveyor, Longford, Ireland.
1890 Mar. 29	Gunyon, C. J., A.M. Inst.C.E.	Surveyor to the Urban District Council, Wood Green, N.

Date of Election and Transfer.		
1891 Dec. 12	**Hackett**, E. A., M.E., M. Inst. C.E.	County Surveyor, Clonmel, Tipperary, Ireland.
1885 June 6	**Haigh**, J., A.M. Inst. C.E.	Borough Surveyor, Abergavenny.
1896 Apr. 25	**Hainsworth**, M.	Surveyor to the Urban District Council, Teddington.
1897 June 19	**Hague**, S.	Borough Surveyor, Dukinfield.
1902 Sept. 6	**Hale**, A.	Municipal Engineer, Howrah, Bengal.
G1899 Dec. 16 T1901 Oct. 19	****Hall**, C.	Surveyor to the Urban District Council, Droylsden, near Manchester.
1902 Nov. 8	**Hall**, E.	Borough Surveyor, Carnarvon.
1884 Apr 19 R1903 Mar. 21	**Hall**, J., M. Inst. C.E. (*Member of Council.*)	Executive Engineer, Municipal Offices, Bombay (*Hon. Secretary*, Indian District).
1886 May 1	**Hall**, W., A.M. Inst. C.E.	Surveyor to the Urban District Council, Great Crosby.
1900 June 16	**Hallam**, R.	Surveyor to the Rural District Council, Eton.
1901 May 11	**Haller**, J. C.	Surveyor to the Urban District Council, Carlton, near Nottingham.
1905 June 22	***Halstead**, B.	Surveyor to the Urban District Council, Brierfield, Lancs.
1894 July 7	**Hamar**, A.	Borough Surveyor, Bishop's Castle, Shropshire.
1887 Mar. 12	**Hamby**, G. H., Assoc.M.Inst. C.E.	Borough Engineer, Lowestoft.
1904 Mar. 26	**Hammond**, H.	County Engineer, Hobson C.C., Auckland, New Zealand.
1897 Feb. 13	**Hamp**, H. J., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, New Swindon.
1897 Mar. 13	**Hanson**, J. H.	Surveyor to the Urban District Council, Cottingham, Yorks.
1890 Sept. 13	**Hanson**, W.	Surveyor to the Urban District Council, Wantage.
1896 Jan. 18	**Hara**, R.	Engineer to Tokio Fu, Japan.
1873 Feb. 15	**Harding**, J. R.	Ashley Road, Epsom, Surrey.
G1896 Nov. 28 T1899 June 10	***Harding**, W. D.	Borough Engineer, Bury St. Edmunds.
1899 June 29	***Hargreaves**, J. E.	Surveyor to the Urban District Council, Farnborough, Hants.
1899 May 6	**Harman**, E. A., M. Inst. C.E.	Corporation Gas Engineer, Huddersfield.
1897 Mar. 13	**Harpur**, A. O.	Surveyor to the Urban District Council, Caerphilly.
1905 Jan. 28	**Harpur**, J. L.	Town Surveyor, Brierley Hill.
1894 Mar. 3	**HARPUR**, W., M. Inst. C.E. (*Past President. Member of Council.*)	City Engineer, Cardiff.
1896 Jan. 18	**Harris**, F.	Surveyor to the Rural District Council, Tonbridge. Bidborough, Tunbridge Wells.
1901 May 11	**Harrison**, A., A.M. Inst. C.E.	Borough Engineer, Southwark. Town Hall, Walworth Road, S.E.

Date of Election and Transfer.		
1899 June 29	**Harrison**, G. F. P.	Surveyor to the Rural District Council, East Stow. Stowmarket, Suffolk.
G1900 Mar. 19 T1905 Mar. 3	*__Harrison__, J. W.	Surveyor to the Urban District Council, Wombwell, Yorks.
1896 Nov. 28 B1904 Jan. 23	**Harston**, W., A.M. Inst. C.E.	8 Hythe Street, Dartford.
1905 Sept. 23	**Hart**, G. A.	Sewerage Engineer, Municipal Buildings, Leeds.
1896 Oct. 24	**Hartley**, T. H.	Borough Surveyor, Colne.
P1887 June 18	**Harty**, S., M. Inst. C.E. I.	City Engineer, Dublin.
1893 Oct. 21	**Harvey**, T. F., Assoc. M. Inst. C.E.	Engineer to the Urban District Council, Merthyr Tydvil.
1892 Apr. 23	**Hawley**, G. W.	Highway Surveyor R.D.C., Basford. York Chambers, King Street, Nottingham.
1902 July 10	**Haynes**, H. T., Assoc. M. Inst. C.E.	City Engineer, Perth, West Australia.
1895 Apr. 20	**Haynes**, R. H.	Borough Engineer, Newport, Mon.
G1897 June 19 T1898 Jan. 15	*__Hayward__, T. W. A., A.M. Inst. C.E.	Borough Surveyor, Town Hall, Battersea.
G1899 Jan. 12 T1903 June 25	*__Haywood__, S. S.	Borough Engineer, Brighouse.
1899 June 10	**Heath**, J.	Surveyor to the Urban District Council, Urmston.
1885 June 6	**Heaton**, G., Assoc. M. Inst. C.E.	Surveyor to the Urban District Councils, Abram and Pemberton. King Street, Wigan.
1890 Feb. 1	**Henderson**, A. J., Assoc. M. Inst. C.E.	Surveyor to the District Highway Board, Kingston-on-Thames.
G1895 June 27 T1901 Oct. 19	*__Hendry__, J. S.	Surveyor to the Urban District Council, Cannock, Staffs.
1897 Feb. 13	**Henry**, T.	Surveyor to the Rural District Council, East Retford.
1903 Dec. 12	**Henshaw**, R. S.	Surveyor to the Urban District Council, Portland.
1892 June 11	**Heron**, J., B.E., B.A.	County Surveyor, Co. Down. Courthouse, Downpatrick, Ireland.
1902 May 10	**Heslop**, R.	Surveyor to the Urban District Council, Tanfield, co. Durham
1875 Dec. 21	**Hewson**, T., M. Inst. C.E.	Late City Engineer, Leeds.
1894 July 7	**Higgens**, T. W. E., Assoc. M. Inst. C.E.	Borough Surveyor, Town Hall, Chelsea, S.W.
1898 May 21	**Higgins**, J.	Chief Engineer, Grey Co., New Zealand.
1898 Dec. 17	**Hinchcliffe**, D.	Surveyor to the Urban District Council, Shepton Mallet.
1902 July 10	*__Hines__, C. E.	Surveyor to the Urban District Council, Windermere.
1898 Sept. 3	**Hirst**, R. P., A.M. Inst. C.E.	Borough Surveyor, Southport.
1895 June 27	**Hodgson**, W.	Surveyor to the Urban District Council, Keswick.

Date of Election and Transfer.		
P1873 Feb. 15 a1885 Dec. 19	Hodson, G., M. Inst. C.E. ..	Loughborough. Abbey Buildings, Prince's Street, Westminster, S.W.
1896 Apr. 25 a1901 May 11	*Hogbin, L. W.	"Rowena," Preston Road, Leytonstone, N.E.
1890 Feb. 1	Holden, J., A.M. Inst. C.E.	Highway Surveyor to the Rural District Council, Llandaff. Ely, Cardiff.
1897 Jan. 16	Hole, W. P.	Borough Surveyor, Montgomery. Crowther's Hall, Welshpool.
1904 Aug. 16	Holmes, F. G.	Burgh Surveyor, Govan, N.B.
1892 Mar. 11	Holmes, G. W., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Walthamstow, N.E.
e1903 Dec. 12 T1904 Oct. 29	*Holt, R. B.	Permanent Way Engineer, Wellington Bridge, Leeds.
1901 Dec. 7	*Holt, W.	Surveyor to the Urban District Council, Sale, Cheshire.
1884 Oct. 9	Hooley, Cosmo C., Assoc. M. Inst. C.E.	Surveyor to the Rural District Council, Barton-upon-Irwell. Croft's Bank House, Davyhulme, nr Manchester.
1884 Oct. 9	Hooley, E. P., A.M.Inst.C.E. (*Member of Council.*)	County Surveyor, Nottingham.
1898 Jan. 15	Hopkinson, F.	Surveyor to the Rural District Council, Blyth and Cuckney. 40 Bridge Street, Worksop.
1889 Sept. 21	Hopkinson, W. H., A.M.Inst. C.E. (*Member of Council.*)	Borough Engineer, Keighley; *Hon. Sec.*, Yorkshire District.
1891 Dec. 12	Horan, J., M.E., M.Inst.C.E.	County Surveyor, 82 George Street, Limerick, Ireland.
1895 July 27	Horsfall, W. H. D.	Surveyor to the Urban District Council, Southowram. 9 Harrison Road, Halifax.
1900 May 19	Horsfield, J. Nixon	Surveyor to the Urban District Council, Hampton Wick. Kingston-on-Thames.
1902 Sept. 6	Hoskins, M.	Surveyor to the Urban District Council, Oystermouth.
1894 Mar. 3	Howard, H.	Surveyor to the Urban District Council, Littlehampton.
P1889 Dec. 14 a1898 Oct. 15	Howard-Smith, W., Assoc. M. Inst. C.E.	"Arosa," Amersham Hill, High Wycombe.
1880 May 27	Howcroft, J...	Surveyor to the Urban District Council, Redcar, Yorkshire.
1894 June 21	Howell, F. G.	County Surveyor, Surrey. Kingston-on-Thames.
1896 Feb. 22	Howse, W. T.	Surveyor to the Urban District Council, Bexley.
1897 June 17	Hughes, H. T.	Highway Surveyor, Hayfield Road. Chapel-en-le-Frith.
e1901 Aug. 24 T1904 Dec. 3	*Hull, G. E., A.M.Inst.C.E.	Resident Engineer, Benares, India.
1897 Jan. 16	Humphreys, J.	Surveyor to the Urban District Council, Maesteg.
1899 June 1	Humphries, H. H.	Surveyor to the Urban District Council, Erdington.
1894 June 21	Hunt, G. J.	Borough Engineer, Dorchester.

Date of Election and Transfer.		
1897 July 8	Hunter, T.	Surveyor to the Urban District Council, Leigh.
G1891 Aug. 1 T1896 Apr. 25	*Hurd, H.	Surveyor to the Urban District Council, Broadstairs.
G1901 Aug. 24 T1901 Dec. 7	*Hutton, F.	Surveyor to the Urban District Council, Ashton-on-Mersey.
A1902 Feb. 22 T1903 Mar. 21	Hutton, S.	Surveyor to the Urban District Council, Exmouth.
1898 May 21	Ingamells, E. W.	Surveyor to the Urban District Council, Pokesdown.
G1895 Apr. 20 T1896 Oct. 24	*Ingham, W., A.M. Inst.C.E.	Hydraulic Engineer, Port Elizabeth, South Africa.
1899 Feb. 25	Ingram, S.	County Surveyor, Devon. Exeter.
1888 Nov. 17	Irving, W. E.	Surveyor, Toowong, Queensland, Australia.
1893 June 24 R1902 Nov. 8	Isaacs, L. H., A. Inst. C.E.	3 Verulam Buildings, Gray's Inn, W.C.
1904 May 28	Iveson, J. A.	Surveyor to the Rural District Council, 2 Nares Street, Scarborough.
1900 July 19	Jack, G. H.	Surveyor to the Urban District Council, Aston Manor.
1893 Oct. 21	Jaffrey, W.	Town Surveyor, Matlock Bath.
1896 Oct. 24	James, A. C., A.M. Inst. C.E.	Surveyor to the Urban District Council, Grays Thurrock. Grays.
1903 Dec. 12	James, C. C., M.Inst.C.E.	Special Drainage Engineer, Municipal Offices, Bombay, India.
1900 Mar. 10	James, J. P.	Frogmore, Tenby.
G1887 Oct. 22 T1890 Mar. 29	*Jameson, M. W., A. M.Inst. C.E.	Borough Engineer, Stepney. Gt. Alie St., Whitechapel, E.
1897 Feb. 13	Jarvis, R. W.	Surveyor to the Rural District Council, Tenbury.
1885 Apr. 18	Jeeves, E.	Surveyor to the Urban District Council, Melton Mowbray.
G1898 Jan. 15 T1903 Oct. 17	*Jeffes, R. H.	Surveyor to the Urban District Council, Cheshunt.
G1896 Jan. 18 T1896 Oct. 24	*Jenkin, C. J., A.M. Inst.C.E.	Surveyor to the Urban District Council, Finchley, N.
1899 June 10	Jenkins, D. M., A.M.Inst.C.E.	Borough Surveyor, Neath.
1880 Feb. 7	Jennings, G.	Borough Surveyor, Rotherham.
1895 May 25	Jepson, J.	Surveyor to the Urban District Council, Levenshulme.
1892 July 21	Jevons, J. H., A.M. Inst. C.E.	Borough Surveyor, Hertford.
1904 May 28	Johnson, J.	Borough Surveyor, Rawtenstall.
1895 June 27	Johnston, J., M. Inst. C.E.	Waterworks Engineer, Brighton.
1883 Aug. 4 R1902 Nov. 8	Jones, V.C., Lt.-Col. A. S., M. Inst. C.E.	Ridge Cottage, Finchampstead, Berks.
1873 Feb. 15	JONES, CHAS., M. Inst. C.E. *(Past President and Gen. Hon. Secretary. Member of Council.)*	Borough Surveyor, Ealing, Middlesex.

Date of Election and Transfer.		
1894 July 7	Jones, Christopher	Borough Surveyor, Hythe, Kent.
G1903 May 16 T1904 June 26	*Jones, F. W.	Surveyor to the Urban District Council, Frome, Somerset.
1874 Jan. 29	Jones, I. M., M. Inst. C.E.	City Surveyor, Chester; Engineer to the Dee Bridge Commissioners.
1894 June 21	Jones, J.	Surveyor to the Rural District Council, Hengoed, *viâ* Cardiff.
1894 June 21	Jones, J. O.	Surveyor to the Rural District Council, Biggleswade.
1903 June 6	Jones, R. R.	Surveyor to the Urban District Council, Horsforth.
1900 Mar. 10	Jones, T. C.	Surveyor to the Urban District Council, Frimley. Camberley, Surrey.
1892 May 28	Jones, W., Assoc.M.Inst.C.E.	Surveyor to the Urban District Council. Colwyn Bay.
1897 Feb. 13	Jones, W. J.	Surveyor to the Urban District Council, Rhondda.
1898 Apr. 23	Jones, W. P.	Surveyor to the Urban District Council, Glyncorrwg.
1891 June 25	Jukes, W. H.	Surveyor to the Urban District Council, Tipton.
1905 Oct. 28	*Kay, G. H.	Surveyor to the Urban District Council, Irlam, Lancs.
1895 July 27 R1899 Dec. 16	Kay, W. R., A.M. Inst. C.E.	Athol Street, Douglas, Isle of Man.
P1889 Feb. 9	Kemp, J., Assoc. M. Inst. C.E.	Engineer to the Municipality of Brisbane, Queensland.
1892 Apr. 23	Kennedy, J. D.	Borough Surveyor, Retford.
1905 Jan. 28	*Kenyon, L.	Surveyor to the Urban District Council, Tottington.
1895 May 25	Keywood, H. G.	Surveyor to the Urban District Council. Hoyland Nether, Barnsley.
1892 July 11	Kidd, T., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Swadlincote, Burton-on-Trent.
1899 Oct. 21	Killick, J. S.	Highway Surveyor to the Rural District Council, Croydon.
1899 June 29	Killick, P. G.	Borough Surveyor, Finsbury, E.C.
1902 May 10 R1903 July 25	Kinnison, A. M.	Abbey Cottage, Leek, Staffs.
1888 Sept. 15	Kirk, T., Assoc. M. Inst. C.E.	Town Engineer, Ipswich, Queensland.
1892 Mar. 11	Kirkby, S. A., M.A., Assoc. M. Inst. C.E.	County Surveyor, Cork (South division), East Riding. Miramur, Queenstown.
1895 Oct. 19	Knapp, R. W.	Borough Surveyor, Andover.
1903 June 25	*Knewstubb, F. W., A.M.Inst. C.E.	Surveyor to the Urban District Council, Haverhill.
1903 June 25	*Knewstubb, J. J.	Surveyor to the Urban District Council, Penrith.
1894 Mar. 3 R1903 Jan. 17	Knight, J. M., A.M.Inst.C.E.	35 Bancroft Road, Mile End, E.

Date of Election and Transfer.		
1884 Oct. 9	Lacey, F. W., M.Inst.C.E. ..	Borough Engineer, Bournemouth.
G1898 Jan. 14 T1895 Mar. 16	*Lacey, G. W.	Borough Surveyor, Oswestry.
1882 May 25 B1902 Jan. 25	Laffan, G. B., M. Inst. C.E.	Hardy's Chambers, Pietermaritzburg.
1900 Dec. 15	Lailey, H. G. N.	Surveyor to the Urban District Council, Trowbridge.
1900 July 19	Laithwaite, V.	Surveyor to the Urban District Council, Turton.
1904 Apr. 30	Lambert, A. P.	P.W.D., Winchester House, Johannesburg, South Africa.
A1902 Mar. 29 T1905 Oct. 28	Lancashire, W. T., Assoc. M.Inst. C.E.	City Engineer, Leeds.
1904 Oct. 13	Landale, G.	Burgh Surveyor, Musselburgh, N.B.
1891 June 6	Landless, J. T., Assoc. M. Inst. C.E.	4 Nicholas Street, Burnley.
1894 June 21 B1902 Nov. 8	Latham, A., M. Inst. C.E. ..	Municipal Buildings, Margate.
1904 Aug. 25	Lawrie, J. P.	Burgh Surveyor, Bo'ness, N.B.
1884 July 10	Lawson, C. G., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Southgate. District Offices, Palmer's Green, N.
1900 Mar. 10	Lawton, C. H.	Surveyor to the Urban District Council, Warminster. Christchurch Cottage, Warminster, Wilts.
G1899 Oct. 21 T1901 May 11	*Lea, M., A. M. Inst. C.E. ..	City Surveyor, Truro.
1904 Aug. 31	Lee, J.	Burgh Surveyor, Paisley, N.B.
1896 Oct. 24	Leebody, J. W.	County Surveyor, Co. Tyrone (S.).
1898 Mar. 19	Leete, H. J. G.	County Surveyor, Huntingdon.
1880 Apr. 10	Leete, W. H., A.M.Inst.C.E.	County Surveyor, Bedford.
1900 May 19	Legg, E. I.	Borough Surveyor, Christchurch, Hants.
1894 May 19	Leigh, W.	Borough Surveyor, Chorley.
1873 Feb. 15	LEMON, J., M. Inst. C.E. (*Past President.*)	Lansdowne House, Southampton; and 11 Victoria Street, Westminster, S.W.
1899 Oct. 21	Lines, E.	Engineer to the Rural District Council, Chesterfield.
G1896 July 25 T1899 Dec. 16 B1903 Feb. 21	*Liversedge, J. W.	Wigan Road, Ashton-in-Makerfield.
1891 Mar. 21 B1901 Aug. 24	Livingstone, G., Assoc. M. Inst. C.E.	Bank House, Lewes Terrace, Hove.
G1895 May 25 T1900 Oct. 15	*Lobley, F., A.M. Inst. C.E.	Town Surveyor, Hale, Cheshire.
1873 May 2	LOBLEY, J., M. Inst. C.E. (*Past President. Member of Council.*)	Borough Engineer, Hanley, Staffordshire.
1896 June 25	Locke, W. R.	Borough Surveyor, Town Hall, Hemel Hempstead.
1889 Sept. 21	Lomax, C. J., Assoc. M. Inst. C.E.	Engineer to the Urban District Council, Gorton. 37 Cross Street, Manchester.
1904 Mar. 26	Longdin, H. W.	Surveyor to the Urban District Council, Penge.

Date of Election and Transfer.		
1896 Oct. 24	LONGFIELD, R. W. F., M. Inst. C.E.	County Surveyor, Co. Cork (W.). Bandon.
1903 Dec. 12	LONGLEY, H. B.	District Surveyor, Town Hall, Manchester.
1902 Nov. 8	LORD, E. I.	Borough Engineer, Greymouth, New Zealand.
1901 May 11	LOVEDAY, W. F.	Borough Surveyor, Stoke Newington, N.
1892 Jan. 16	LOVEGROVE, E. J., M. Inst. C.E.	Borough Engineer, Hornsey, N.
1897 July 8	LUMSDEN, J. L.	Burgh Surveyor, Kirkcaldy.
1896 July 25	LUND, C.	Surveyor to the Urban District Council, Cleckheaton.
1896 Oct. 24	LYNAM, F. J., Assoc. M. Inst. C.E.	County Surveyor, Co. Tyrone (N.).
E1888 July 12 T1897 Oct. 16	*LYNAM, G. T., Assoc. M. Inst. C.E.	Borough Surveyor, Burton-on-Trent.
1891 Aug. 1	LYNAM, P. J.	County Surveyor, Louth. Dundalk, Ireland.
1873 May 2 R1900 Mar. 10	MCBEATH, A. G., Assoc. M. Inst. C.E.	Montagu Road, Sale, Cheshire.
1905 Mar. 8	MCBETH, M. B.	Surveyor to Mid-Argyll District, Argyllshire County Council. Kilmory Cottage, Lochgilphead, Argyllshire.
1883 May 30	MACBRAIR, R. A., M.Inst.C.E.	City Engineer, Lincoln.
1904 Aug. 24	MCBRIDE, S.	Burgh Surveyor, Rutherglen, N.B.
1900 Feb. 10	MCDERMID, C.	Surveyor to the Urban District Council, Eston.
1897 Feb. 13	MCDONALD, A. B., M. Inst. C.E. (*Member of Council.*)	City Engineer, Glasgow.
1904 Oct. 29	MACGREGOR, J. M.	Highway Surveyor to the Rural District Council, 14 Market Place, Morpeth.
1897 Jan. 16	MACKENZIE, D.	County Surveyor, Dunfermline.
1895 Oct. 19	MCKENZIE, J. MCD.	Surveyor to the Rural District Council, Bucklow. 7 Market Street, Altrincham.
1904 Oct. 1	MACKIE, G. D.	Burgh Surveyor, Crieff, N.B.
1879 Oct. 23 R1889 Oct. 19	MCKIE, H. U., M. Inst. C.E.	The White House, Spondon, Derby.
1898 June 30	MCKILLOP, R.	Burgh Surveyor, Perth, N.B.
1898 Feb. 19	MADIN, W. B.	Surveyor to the Urban District Council, Rushden.
1897 Mar. 13	MAGER, F. W., Assoc. M. Inst. C.E.	P. W. D. Kuala, Lumpur, Selangor, S. Settlements.
1886 Dec. 18	MAIR, H., M. Inst. C.E.	Borough Engineer, Hammersmith, W.
1900 Feb. 10	MALLINSON, J.	Surveyor to the Urban District Council, Skipton.
E1891 Jan. 21 T1897 June 19 R1904 Jan. 23	*MANLEY, J.	7 Oxford Road, Wokingham.
1892 July 21	MANNING, G. W.	Surveyor to the Rural District Council, Staines.
E1898 Jan. 15 T1901 Aug. 24	*MARKS, C. W.	Borough Surveyor, Wokingham.
1888 July 12	MARKS, H. C., M. Inst. C.E.	City Surveyor, Carlisle.

Date of Election and Transfer.		
1899 May 6	Marks, W. L.	Surveyor to the Urban District Council, Rhymney.
1897 Mar. 13	Marshall, J.	Surveyor to the Rural District Council, West Malling.
1891 Jan. 21 R1902 Nov. 8	Marston, C. F., Assoc. M. Inst. C.E.	Masonic Hall Chambers, Mill Street, Sutton Coldfield.
1894 Mar. 8	Marten, H. J., Assoc. M. Inst. C.E.	Borough Surveyor, Eastern District, Wandsworth. 215 High Road, Balham, S.W.
1890 Mar. 29 R1898 Mar. 19	Mason, C., Assoc.M.Inst.C.E.	The Elms, Beeston, near Nottingham.
1899 May 6	Mason, C. G., Assoc. M. Inst. C.E.	Borough Surveyor, Guildford.
1904 Oct. 22	Massie, C.	Water Engineer, Falkirk, N.B.
1890 Mar. 29	Massie, F., A.M. Inst. C.E.	Surveyor to the Rural District Council, Wakefield.
1904 Aug. 17	Massie, J.	Burgh Engineer, Edinburgh, N.B.
1883 Feb. 17	Mathews, G. S., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Dorking.
1898 Dec. 17	*Matthews, E. R.	Surveyor to the Urban District Council, Bridlington.
1904 May 28	Maudsley, C. W.	Surveyor to the Rural District Council, Oakham, Rutland.
1881 Dec. 10	MAWBEY, E. G., M. Inst. C.E. (*Past President.*)	Borough Engineer, Leicester.
1892 Mar. 11	Mawson, R. C.	Borough Surveyor, Evesham.
G1896 July 25 T1902 Sept. 6	*Maxwell, W. H., Assoc. M. Inst. C.E.	Borough Surveyor, Tunbridge Wells.
G1898 Dec. 17 T1904 June 26	*May, C. G.	Superintendent of Works and Surveys, P.W.D., Singapore.
1875 May 1	MAY, F. J. C., M. Inst. C.E. (*Past President.*)	8-11 Pavilion Buildings, Brighton.
1894 Oct. 20	Maybury, H. P.	County Surveyor, Maidstone.
1901 Aug. 24	Maylan, S.	Surveyor to the Rural District Council, Basford.
1889 May 18	Mayne, C., M. Inst. C.E.	Engineer and Surveyor to the Municipal Council. Shanghai *Hon. Corresponding Sec.* for Eastern Asia
1883 Feb. 17	MEADE, T. DE COURCY, M. Inst. C.E. (*Past President.*)	City Surveyor, Manchester.
1888 July 12	*Metcalf, J. W., Assoc. M. Inst. C.E.	Town Surveyor, Newmarket.
1903 June 25	*Metcalfe, A. J.	Surveyor to the Rural District Council, Bourne.
1890 June 7	Middleton, R. H., Assoc. M. Inst. C.E.	Borough Surveyor, Walsall.
1893 June 24	Miller, H., M. Inst. C.E.	County Surveyor, East Suffolk. Ipswich.
1902 July 10	Miller, H.	Surveyor to the Urban District Council, Heysham.
1897 Jan. 16	*Milnes, G. P., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Stroud.
1874 May 23	Mitchell, J.	Borough Surveyor, Hyde, Manchester.

Date of Election and Transfer.		
1896 Oct. 24	Moncur, J., A.M. Inst. C.E.	County Highway Surveyor, County Buildings, Stafford.
1900 Dec. 15	Monteath, G.	County Surveyor, Newtown, St. Boswell's, N.B.
1898 Apr. 23	Morgan, E. F.	Borough Road Surveyor, Croydon.
1895 July 27	Morgan, G. S.	Surveyor to the Rural District Council, Llantrissant, Glamorgan.
1892 July 11	Morgan, J.	Surveyor to the Rural District Council, Pontardawe. Swansea.
1901 June 8	Morgan, R. P.	Surveyor to the Urban District Council, Towyn.
1874 May 1	Morgan, W. B., Assoc. M. Inst. C.E.	Borough Surveyor, Weymouth and Melcombe Regis, Dorsetshire.
1905 Oct. 28	Morley, E.	Surveyor to the Urban District Council, Walthamstow.
1898 June 30	Morris, F. J...	Borough Surveyor, Grantham.
1903 Feb. 21	Moulding, T., A.M.Inst.C.E.	City Surveyor, Exeter.
A1902 Jan. 25 T1902 June 7	*Mount, J. C., A.M. Inst. C.E.	Borough Surveyor, Lancaster.
1885 Feb. 7 R1905 Jan. 28	Mountain, A. H., Assoc. M. Inst. C.E.	14 Prince's Chambers, 16 John Dalton Street, Manchester.
1898 Sept. 3	Mulvany, C. J., M. Inst. C.E.	County Surveyor, Athlone.
1890 Mar. 29	Murch, P.	Borough Engineer, Portsmouth.
1896 Nov. 28	Murphy, P. E., M.Inst. C.E.	Engineer to the Tottenham and Wood Green Joint Drainage Committee. Council Buildings, Tottenham, N.
1904 Aug. 6	Murray, J.	County Surveyor, Renfrewshire. Paisley, N.B.
1904 Aug. 17	Murray, J.	Burgh Surveyor, Port Glasgow, N.B.
1895 Feb. 16 R1904 Jan. 23	Murzban, Khan Bahadur M. C., C.I.E., M. Inst. C.E.	"Gulestan," Murzban Road, Bombay.

1896 Oct. 24	Nankivell, H. H.	Surveyor to the Urban District Council, Braintree.
G1903 Oct. 17 T1905 May 27	*Nash, F. O. C., Assoc. M.Inst. C.E.	Surveyor to the Urban District Council, Cockermouth.
1905 Oct. 28	Nelson, G., A.M.Inst. C.E.	Surveyor to the Urban District Council, Gosforth.
1893 July 31	*Nettleton, H., Assoc. M. Inst C.E.	Surveyor to the Urban District Council, Weston-super-Mare.
1897 July 8	Newman, S. J.	Surveyor to the Urban District Council, Branksome.
1897 Feb. 13 R1903 Jan. 17	Newton, C. E.	19 Cooper Street, Manchester.
G1895 Jan. 19 TA1901 Oct. 19 T1902 Mar. 22	*Newton, E. B., A.M. Inst. C.E.	Borough Surveyor, Paddington, W.
1891 Oct. 17	Newton, G. H.	Surveyor to the Urban District Council, Denton, Manchester.

Date of Election and Transfer.		
1888 May 12	Newton, W. J., A.M.Inst.C.E.	Borough Surveyor, Accrington.
G1892 Sept. 24 T1899 Feb. 25	*Nichols, A. E., A.M. Inst.C.E.	Borough Engineer, Folkestone.
1904 Aug. 5	Nisbet, T., Assoc. M.Inst.C.E.	Master of Works, City Chambers, Glasgow, N.B.
1887 July 14 R1899 Feb. 25	Norrington, J. P., Assoc. M. Inst. C.E.	17 Victoria Street, Westminster, S.W.
G1897 Mar. 13 T1898 Sept. 3	*Norris, J. H.	Borough Surveyor, Godalming.
1886 Dec. 18 R1901 May 11	Norrish, G. R.	Hawley House, Tudor Road, Upper Norwood.
1900 Dec. 15	Nuttall, H., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Kearsley.
1899 Feb. 25	Nuttall, W.	Surveyor to the Urban District Council, Prestwich.
G1898 June 30 T1899 Oct. 21	*Oakden, R., A.M. Inst. C.E.	Surveyor to the Rural District Council, Newark.
1901 Aug. 24	O'Hara, H.	Surveyor to the Urban District Council, Ballymena, Ireland.
1892 Jan. 16	Oxtoby, W., M. Inst. C.E.	Borough Engineer, Camberwell, S.E.
1896 Apr. 25	Palmer, F. W. J.	Surveyor to the Urban District Council, Herne Bay.
P1900 Mar. 10	Palmer, P. H., M. Inst. C.E.	Borough Surveyor, Hastings.
1905 Jan. 28	Pansing, J., A.M. Inst. C.E.I.	Town Surveyor, Wicklow.
1894 Apr. 6	Pardoe, J. C., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Barry, near Cardiff.
1876 May 1	Parker, J., Assoc. M. Inst. C.E.	City Surveyor, Hereford.
1887 July 14 R1895 June 27	Parker, J., A.M. Inst. C.E.	49 Denmark Villas, Hove, Brighton.
1896 Nov. 28 R1903 Feb. 21	Parker, J. E., A.M.Inst.C.E.	P.O. Chambers, St. Nicholas Square, Newcastle-on-Tyne.
1896 Oct. 24	Parker, S. W.	Surveyor to the Urban District Council, Gainsborough.
1893 July 13	Parr, F., Assoc. M. Inst. C.E.	Borough Surveyor, Bridgwater.
G1898 June 30 T1899 Oct. 21	*Parr, F. H.	Borough Surveyor, Lymington.
G1893 Jan. 14 T1894 Oct. 20	*Parr, N.	Surveyor to the Urban District Council, Brentford.
1905 June 22	*Parry, E.	Surveyor to the Rural District Council, Long Crendon, Bucks.
P1894 June 21	Paton, J. (*Member of Council.*)	Borough Engineer, Plymouth.
1905 June 22	Pattinson, N. P.	Borough Surveyor, Gateshead.
1895 Jan. 19	Pattison, W. P.	Surveyor to the Urban District Council, Benwell and Fenham.
1897 Jan. 16	Peacock, T. J.	Surveyor to the Rural District Council, Spalding.
1898 Dec. 17	Pearce, F. W.	Surveyor to the Urban District Council, Twickenham.
1899 Oct. 21	Peet, H. F., M. Inst. C.E.	City Engineer, Bloemfontein, South Africa.
1891 Dec. 12	Peirce, R., M. Inst. C.E.	Municipal Engineer, Singapore, S.S.

Date of Election and Transfer.		
1896 Nov. 28	Perrins, B.	Surveyor to the Urban District Council, Redditch.
1891 Sept. 12	Perry, J., M.E., M.Inst.C.E.	County Surveyor, Co. Galway (West Riding), Galway.
1898 May 21	Petch, W. J.	Surveyor to the Urban District Council, Leigh-on-Sea, Essex.
1889 May 18	Phillips, R., Assoc. M. Inst. C.E.	County Surveyor, Gloucester.
1904 May 28	Phipps, F. R., Assoc.M. Inst. C.E.	Borough Surveyor, Basingstoke.
1901 Aug. 24	Pick, S. P.	County Surveyor, Leicester. 6 Millstone Lane, Leicester.
1901 Oct. 19	Pickard, J. E.	Borough Surveyor, Pontefract, Yorks.
1898 Apr. 23	Picker, E.	Surveyor to the Rural District Council, Beverley.
G1887 June 18 PPT1890 Sept. 13	*Pickering, J. S., M. Inst. C.E. (*Member of Council.*)	Borough Engineer, Cheltenham. *Hon. Secretary*, Western District.
1881 Dec. 10 R1884 May 29	Pickering, R.	11 Lowther Street, Whitehaven.
G1894 Jan. 13 T1895 Oct. 19	*Pickering, S. A., A.M. Inst. C.E.	Borough Surveyor, 86 Waterloo Street, Oldham.
G1894 Jan. 13 T1895 Oct. 19	*Pickles, G. H., A.M.Inst.C.E.	Borough Surveyor, Burnley.
P1881 Dec. 10	Platt, S. S., M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Rochdale.
1893 Oct. 21	Plowright, A. H...	Borough Engineer, Wisbech, Cambs.
1884 Mar. 15 R1885 Oct. 8	Pollard, J., M. Inst. C.E. ..	31 Old Queen Street, Westminster, S.W.
1897 July 8	Poole, H. C.	Surveyor to the Urban District Council, Wath-upon-Dearn.
1881 July 7	Porter, R.	Borough Surveyor, Wakefield.
1899 Jan. 21 R1901 May 11	Powell, J.	4–6 Victoria Chambers, Terminus Street, East London, Cape Colony.
1899 Oct. 21	*Prescott, A. E.	Borough Surveyor, Eastbourne.
1898 Mar. 19	Prescott, W. H., A.M. Inst. C.E.	Surveyor to the Urban District Council, Tottenham, N.
1892 Jan. 16	Press, W. J.	Surveyor, Burnham, Somerset.
G1894 June 21 T1899 June 29	*Price, A. J.	Surveyor to the Urban District Council, Lytham.
1879 May 1	Price, J., M. Inst. C.E. (*Vice-President.*)	City Surveyor, Birmingham.
1904 Sept. 29	Pritty, J.	Burgh Engineer, Selkirk, N.B.
1873 May 2	Proctor, J., M. Inst. C.E. ..	Mere Lawn, Bolton, Lancashire.
1892 May 28	Prouse, O. M., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Ilfracombe.
1904 Aug. 4	Purdie, W. H.	Burgh Engineer, Hamilton, N.B.
1873 May 2	Purnell, E. J.	Water Engineer, Coventry, Warwickshire.
1899 May 6	Purser, W. B., A.M. Inst. C.E.	County Surveyor, Kesteven County Council. Grantham.

Date of Election and Transfer.		
G1898 July 31 T1898 June 13	*Putman, W. E., A. M. Inst. C.E.	Borough Surveyor, Morley.
1897 May 15	Pym-Jones, I.	City Surveyor, Chichester.
1886 Dec. 18 R1901 Oct. 19	Radford, J. C., A. M. Inst. C.E.	163 Upper Richmond Road, Putney, S.W.
1889 July 4	Rapley, W.	Surveyor to the Rural District Council, Dorking.
1898 Apr. 23	Rayner, F. J.	Surveyor to the Urban District Council, Newhaven.
1878 May 1	Read, R., A.M. Inst. C.E. (*Member of Council.*)	City Surveyor, Gloucester.
G1897 June 19 TA1901 Dec. 7 T1904 Sept. 17	*Redfern, J. L.	Borough Surveyor, Gillingham, Kent.
1898 Dec. 17	Reid, R. M.	Highway Surveyor to the Stirlingshire County Council, Barnsdale House. Whins of Milton.
1897 Feb. 13	Renwick, R.	Surveyor to the Urban District Council, Horsham.
1892 Mar. 11	Reynolds, E. J., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Friern Barnet.
1888 July 12 R1902 Feb. 22	Richards, R. W., M. Inst. C.E.	Mutual Life of N.Y. Building, Martin Place, Sydney.
1888 May 12	Richardson, H., Assoc. M. Inst. C.E. (*Member of Council.*)	Surveyor to the Urban District Council, Handsworth, Birmingham. *Hon. Secretary*, Midland District.
1884 Oct. 9	Richardson, J.	County Surveyor, Rutland. Stamford.
1901 May 11	*Ridler, W.	Borough Surveyor, Tewkesbury.
1892 Mar. 11	Ridout, A. R.	Surveyor to the Urban District Council, Stone.
1896 Nov. 28	Roberts, D.	Borough Surveyor, Lewes.
G1891 Dec. 12 T1897 Mar. 13	*Roberts, F., A. M. Inst.C.E.	Borough Engineer, Worthing.
1891 Oct. 17	Robinson, W. P., A.M. Inst. C.E.	Surveyor to the Urban District Council, Skelton-in-Cleveland.
1886 May 1	Robinson, W. J.	City Surveyor, Londonderry.
1876 May 1	ROBSON, O. C., M. Inst. C.E. (*Past President. Member of Council.*)	Surveyor to the Urban District Council, Willesden, Middlesex.
1896 Mar. 21	Rodwell, A.	Surveyor to the Rural District Council, Skipton.
1896 Jan. 18	Rogers, W. E.	Surveyor to the Urban District Council, Rugely.
1904 Oct. 22	Ronald, D.	Burgh Engineer, Falkirk, N.B.
1895 Jan. 19	Ross, J. C., A.M. Inst. C.E.	Town Engineer, Warrnambool, Victoria, Australia.
G1901 Feb. 16 T1905 Mar. 3	*Rothera, A.	Surveyor to the Urban District Council, Thornhill, near Dewsbury.
1880 Oct. 2 R1905 May 27	Rounthwaite, R. S., M. Inst. C.E.	3 Willis Street, Wellington, New Zealand.

Date of Election and Transfer.		
1888 May 12	Ruck, F. W.	County Architect, 86 Week Street, Maidstone.
1895 Feb. 16	Rushbrooke, T. J.	Borough Surveyor, High Wycombe.
1896 Apr. 25	*Rushton, E.	Surveyor to the Urban District Council, Cleethorpes.
A1903 Mar. 21 T1904 Sept. 17	Ryman, F. B., A.M.Inst.C.E.	Borough Surveyor, Stamford.
1890 Mar. 29 R1904 Mar. 26	*Saise, A. J., Assoc. M. Inst. C.E.	Eagle Insurance Buildings, Baldwin Street, Bristol.
1899 Feb. 25	Salkield, T.	Chief Engineer to Municipality of Delhi, India.
G1887 June 18 T1898 May 21	*Saunders, J., A.M. Inst. C.E.	Imperial Chambers, Newark.
1894 Mar. 3	Saville, J.	Town Surveyor, Heckmondwike.
1899 May 6	Schofield, W. H., A.M. Inst. C.E.	County Surveyor, Lancashire. County Hall, Preston.
1894 June 21	Scorgie, N., M. Inst. C.E.	Borough Surveyor, Hackney, N.E.
1892 Sept. 24	Scott, A. F.	Surveyor to the Urban District Council, Cromer.
1888 Nov. 17	Scott, H. H., A.M.Inst.C.E.	Engineer to the Commissioners, Hove.
1901 Aug. 24	Scott, J. H.	Surveyor to the Urban District Council, Winton, Bournemouth.
1880 May 27	Scott, R. S., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Bishop's Stortford.
1897 Feb. 13	Scott, T.	Aberford, near Leeds.
1904 Aug. 4	Scott, T. H.	Burgh Surveyor, Inverness, N.B.
1897 July 8	Senior, C. E.	Surveyor to the Urban District Council, Neston, Cheshire.
1896 Oct. 24	Senior, J. S.	Surveyor to the Urban District Council, Swanage.
G1894 July 7 T1898 Mar. 19	*Settle, J. A., A.M.Inst.C.E.	Borough Engineer and Surveyor, Heywood, Manchester.
1873 May 2 R1903 May 16	Sharman, E.	Croyland Abbey, Wellingborough, Northamptonshire.
1896 Nov. 28	Sharpe, J. E.	Surveyor to the Urban District Council, Otley, Yorks.
1891 June 6	Shaw, H., Assoc.M.Inst.C.E.	Surveyor to the Urban District Council, Ilford.
1890 June 7 R1901 Aug. 24	Shaw, J. H.	Shenstone Cottage, Brownhills, Staffs.
1892 May 28	Sheard, W. C., Assoc.M. Inst. C.E.	"Stonelea," Newtown, New Mills, near Stockport.
1905 June 22	Shell, W. S.	Surveyor to the Urban District Council, Consett, Durham.
1891 Oct. 17	Shepherd, G. J.	Surveyor to the Rural District Council, Kidderminster.
1884 June 10	Sheppard, G.	Borough Surveyor, Newark.
1892 July 11	Shillington, H., M.E.	Town Surveyor, Lurgan, Ireland.

Date of Election and Transfer.		
1895 Oct. 19	Shipton, T. H.	Surveyor to the Urban District Council, Oldbury.
1902 June 7	Siddalls, J.	Borough Surveyor, Tiverton.
1887 Oct. 22	Siddons, J. M.	Surveyor to the River Nene Commissioners, Oundle.
1896 Jan. 18	Sidwell, H. T.	Surveyor to the Rural District Council, Rochford, Essex.
P1887 July 14 R1898 Oct. 15	*Silcock, E. J., M. Inst. C.E.	10 Park Row, Leeds.
1897 Mar. 13	Silcock, H.	Surveyor to the Rural District Council, Blackwell. 67 Westgate, Mansfield.
1903 June 25	Simcox, G.	Borough Surveyor, Dunstable, Beds.
1903 Oct. 17	Simmonds, T. B	Surveyor to the Urban District Council, New Malden.
1904 May 28	*Simmons, R.	Surveyor to the Urban District Council, Little Woolton, near Liverpool.
1901 Feb. 16	Simpson, H. F.	County Surveyor, Northern Division, Isle of Ely. Wisbech.
1891 Aug. 1 R1895 June 27	Simpson, W. H., A. M. Inst. C.E.	Horsefair Street, Leicester.
1890 Sept. 13	Sinclair, J.S., A.M. Inst. C.E.	Borough Surveyor, Widnes.
1895 Oct. 19	Skelton, R., A.M. Inst. C.E.	Municipal Engineer, Colombo, Ceylon.
1899 Oct. 21	Slocombe, D. W.	Surveyor to the Urban District Council, Brynmawr.
1898 Oct. 15	Smail, J. M., M. Inst. C.E.	Chief Engineer to the Metropolitan Board of Works, Sydney, N.S.W.
1898 June 30	Smales, J. E.	Surveyor to the Urban District Council, Leatherhead.
1895 June 27	Smillie, J. F.	Borough Surveyor, Tynemouth.
1899 Dec. 16	Smith, Arthur	Borough Surveyor, Dartmouth.
1892 Mar. 11	Smith, C. Chambers	Surveyor to the Urban District Council, Sutton, Surrey.
1902 Sept. 6	Smith, F. H.	Surveyor to the Urban District Council, Portishead.
G1904 May 28 T1904 Sept. 17	*Smith, F. Hall	Surveyor to the Urban District Council, Swaffham.
1899 Mar. 25	Smith, H. W., A.M. Inst. C.E.	Borough Engineer, Scarborough.
1892 Mar. 11	Smith, J., B.E., M. Inst. C.E.	County Surveyor, Co. Galway (E. Riding), Ballinasloe.
1897 May 15	Smith, James	Borough Surveyor, Buckingham.
1895 May 25	Smith, J. B.	Surveyor to the Urban District Council, Tyldesley.
1899 Oct. 21	Smith, J. D.	County Surveyor's Office, Dalbeattie, Kirkcudbrightshire.
1901 Dec. 7	Smith, J. Gould, A.M. Inst. C.E.	Borough Surveyor, Beverley.
1905 Jan. 28	*Smith, J. H. W.	Surveyor to the Urban District Council, Minehead.
G1898 Dec. 17 TA1901 Oct. 19 T1903 Oct. 17	*Smith, J. W.	Borough Surveyor, Barrow-in-Furness.
1904 Aug. 6	Smith, P. C.	Burgh Surveyor, Arbroath, N.B.
1891 Dec. 12	Smith, T. B., A.M. Inst. C.E.	Surveyor to the Urban District Council, Kettering.
1897 Jan. 16	Smith, V.	Borough Surveyor, Chesterfield.

Date of Election and Transfer.		
G1888 Jan. 14 T1897 Mar. 13	*Smith-Saville, R. W., Assoc. M. Inst. C.E.	Borough Surveyor, Darwen.
1887 Sept. 13	Smythe, F.	Surveyor, Finchley, N.
1898 Jan. 15	Snell, J. F. C., M.Inst.C.E.	Borough Electrical Engineer, Sunderland.
1903 Oct. 17	Sowden, M.	Surveyor to the Urban District Council, Whitchurch, Salop.
1898 Dec. 17	Spencer, J.	Surveyor to the Urban District Council, Oakworth. York Chambers, Cooke Street, Keighley.
1873 May 2 R1881 Dec. 10	Spencer, J. P., A.M.Inst.C.E.	13 Grainger Street West, Newcastle-on-Tyne.
1902 May 10	Spencer, L. G. P., A.M. Inst. C.E.	Surveyor, New Plymouth, New Zealand.
P1885 June 25 R1888 Sept. 15	Spinks, W., M. Inst.C.E. ..	39 Prudential Assurance Buildings, Park Row, Leeds.
G1899 Dec. 16 TA1901 Oct. 19 T1904 July 14	*Spreckley, J. A., Assoc. M. Inst. C.E.	Borough Surveyor, Ludlow.
1880 Feb. 7 R1899 June 10	Stainthorpe, T.W., A.M.Inst. C.E	P.W.D., Cape Town, South Africa.
1889 Dec. 14	Stallard, S., A.M. Inst. C.E.	County Surveyor, Oxfordshire. Oxford.
1892 Mar. 11	Stephenson, E. P., Assoc. M. Inst. C.E.	Town Surveyor, Llandudno.
1890 Mar. 29	Stevens, L.	Surveyor to the Urban District Council, Newton Abbott, Devon.
1892 Mar. 11	Stevenson, A.	District Surveyor, Ayrshire County Council.
1891 Oct. 17	Stevenson, J.	Surveyor to the Urban District Council, East Molesey.
1901 Feb. 16	Stewart, J.	Surveyor to the Urban District Council, Leighton Buzzard.
1891 June 25	Stickland, E. A., Assoc. M. Inst. C.E.	Borough Surveyor, Windsor.
1897 Jan. 16	Stilgoe, H. E., M. Inst. C.E.	Borough Engineer and Surveyor, Dover.
1900 Dec. 15	Stiven, E. E.	Borough Surveyor, Whitehaven.
1887 Sept. 17	Stokoe, J.	Surveyor to the Urban District Council, Altrincham.
1904 Jan. 23	*Stones, J.	Surveyor to the Rural District Council, Sedgfield, co. Durham.
1898 Mar. 19	Stow, J. F.	Surveyor to the Rural District Council, Uxbridge.
1903 Mar. 11	Streather, W. T.	Surveyor to the Urban District Council, Waltham Cross.
G1893 June 24 T1893 July 13	*Stringfellow, W., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Ashbourne, Derbyshire.
1880 May 27	Stubbs, W., A.M. Inst. C.E.	Borough Engineer, Blackburn.
G1892 July 11 T1892 Sept. 24	*Sumner, F., M. Inst. C.E. ..	City Engineer, Guildhall, London, E.C.
1895 Mar. 16	*Surtees, R. T.	Water Engineer to the Urban District Council, Newton-in-Makerfield. Newton-le-Willows, Lancs.

Date of Election and Transfer.		
1904 Aug. 10	Sutherland, J. R., A.M.Inst. C.E.	Chief Engineer, Water Department, City Chambers, Glasgow, N.B.
G1899 June 29 T1901 June 27	*Swales, T. R.	Borough Surveyor, Maldon.
1880 June 23 R1889 Apr. 13	Swarbrick, J., M. Inst. C.E.	30 St. Anns Street, Manchester.
1899 June 10	Sykes, M. H.	Borough Surveyor, Stockton-on-Tees.
1887 Mar. 12	Tanner, W.	County Surveyor, Monmouthshire. Newport.
1895 Mar. 16	Tarbit, T. H.	Surveyor to the Urban District Council, Loftus, Yorkshire.
1891 Mar. 21 R1903 Mar. 21	Taylor, H. W., Assoc. M. Inst. C.E.	St. Nicholas Chambers, Amen Corner, Newcastle-on-Tyne.
1890 Sept. 13	Taylor, T. G.	Borough Surveyor, Ramsgate.
G1891 Sept. 12 T1897 Oct. 16	*Taylor, W. J., M. Inst. C.E.	County Surveyor, Hants. Winchester.
1892 Apr. 23	Terrill, W.	Surveyor to the Urban District Council, Ashford, Kent.
1901 Feb. 16	*Thomas, R. A.	Moelwyn View, South Beach, Pwllheli.
1892 Mar. 11	*Thomas, R. J., M. Inst. C.E. (*Member of Council.*)	County Surveyor, Bucks. Aylesbury. *Hon. Secretary*, Home District.
1890 May 3	Thomas, T. J., A.M.Inst.C.E.	Surveyor to the Urban District Council, Ebbw Vale.
1902 May 10	Thomas, W. B.	Surveyor to the Urban District Council, Southwick-on-Wear.
1887 Sept. 17	Thomas, W. E. C., A.M. Inst. C.E. (*Member of Council.*)	Surveyor to the Rural District Council, Neath; *Hon. Secretary*, South Wales District.
1891 Jan. 21	Thorpe, J.	Surveyor to the Rural District Council, Macclesfield.
1898 Jan. 15	Thropp, J., M. Inst. C.E.	County Surveyor, Lincolnshire. 29 Broadgate, Lincoln.
1898 Apr. 23	Thwaites, W., M. Inst. C.E.	Chief Engineer to the Metropolitan Board of Works, Melbourne, Australia.
G1898 June 30 T1903 Dec. 12	*Tiffin, T. E., A.M.Inst.C.E.	Surveyor to the Urban District Council, Dartford, Kent.
G1891 June 6 T1893 Oct. 21	*Tomes, G. B., A.M. Inst. C.E.	Surveyor to the Urban District Council, Barnes, Mortlake.
1895 Mar. 16	Tooley, H.	Surveyor to the Urban District Council, Buckhurst Hill, Essex.
1890 May 3	Towlson, S., A.M. Inst. C.E.	Surveyor to the Urban District Council, Sevenoaks.
1894 Oct. 20	Travers, W. H.	Surveyor to the Urban District Council, Wallasey.
1897 Jan. 16	Tressider, W. H.	Borough Surveyor, Falmouth.
1901 Feb. 16	Trowsdale, T. J.	Surveyor to the Urban District Council, Annfield Plain. Hare Law, Annfield Plain, Co. Durham.
1893 Oct. 21	Turley, A. C., Assoc.M.Inst. C.E.	City Engineer, Canterbury.

Date of Election and Transfer.		
1890 Oct. 18	TURNBULL, A. J.	Burgh Surveyor, Greenock, N.B.
1897 Mar. 13	TURNER, H. H.	Surveyor to the Rural District Council, Limehurst, Lancs. 250 Oldham Road, Waterloo, near Ashton-under-Lyne.
1899 June 10	*TURNER, S.	Surveyor to the Rural District Council, Ashby-de-la-Zouche.
1898 June 30	TURRIFF, A. A.	Burgh Surveyor, Elgin, N.B.
1905 May 27	*UREN, F. C.	Surveyor to the Urban District Council, Aldershot.
1889 Sept. 21	VALLANCE, R. F.	Borough Surveyor, Mansfield.
1887 Oct. 22	VALON, W. A. McINTOSH, Assoc. M. Inst. C.E.	Ramsgate Corporation Gas-works Engineer. 140 and 141 Temple Chambers, Temple Avenue, E.C.
G1894 Jan. 13 T1901 Dec. 7 R1903 Feb. 21	*VEIT, L. J.	1 Pimlico Road, S.W.
1889 Sept. 21 R1903 Jan. 17	VENTRIS, A., Assoc. M. Inst. C.E.	"Campton," Arkwright Road, Hampstead, N.W.
1897 June 19	VINCENT, S. J. L., A. M. Inst. C.E.	Borough Surveyor, Newbury.
1894 June 21	WADDINGTON, J. A. P., M. Inst. C.E.	Borough Engineer, Marylebone, W.
1902 June 7	WAKEFORD, J. P., A. M. Inst. C.E.	Surveyor to the Urban District Council, Bilston.
1888 July 12	WAKELAM, H. T., M. Inst. C.E. (*Member of Council.*)	County Engineer, Middlesex. Guildhall, Westminster, S.W.
1898 Sept. 3	WALKER, A. H., A. M. Inst. C.E.	Borough Surveyor, Loughborough.
G1900 Dec. 15 T1904 Jan. 23	*WALKER, H.	Surveyor to the Urban District Council, Wealdstone.
P1873 May 2	WALKER, T.	"Akestead," Harriotts Lane, Ashstead.
1887 June 18	WALSHAW, J. W.	Borough Surveyor, Peterborough.
1905 Sept. 23	WARBURTON. W. E.	Surveyor to the Urban District Council, Hornsea.
1899 Jan. 21	WARD, J., M. Inst. C.E.	Borough Engineer, Derby.
1904 Jan. 23	WARD, T., Assoc. M. Inst. C.E.	Borough Engineer, Lower Hutt. 4 Grey Street, Wellington, New Zealand.
1886 July 8	WARDLE, J. W., A. M. Inst. C.E.	Borough Surveyor, Longton.
G1900 May 19 T1905 Mar. 3	*WARLOW, W. R.	Surveyor to the Urban District Council, Milton-next-Sittingbourne.
G1904 May 28 T1904 Sept. 17	*WARR, G. W.	Surveyor to the Urban District Council, Southwick.
1890 May 3	WATERHOUSE, D.	Surveyor to the Urban District Council, Watford.

Date of Election and Transfer.		
1892 Mar. 11	Watkeys, G., A.M.Inst.C.E.	Surveyor to the Urban District Council, Llanelly.
1887 June 18	Watson, J. D., M. Inst. C.E.	Engineer to the Birmingham, Tame and Rea Drainage Board, Council House, Birmingham.
1904 Aug. 10	Watson, W.	Burgh Surveyor, St. Andrews, N.B.
1889 Sept. 21	Watts, E. T.	Surveyor to the Rural District Council, Hadham and Stansted, Bishop's Stortford.
1893 Oct. 21	Watts, W., A.M.Inst. C.E.	Water Engineer, Langsett, near Penistone.
1899 Jan. 21	Weaver, H. J.	Surveyor, King's Lynn.
1887 June 18	WEAVER, W., M. Inst. C.E. (*Past President. Member of Council.*)	Borough Engineer, Kensington, W.
1900 Oct. 15	Webb, H.	Garden City Waterworks, Sun Street, Baldock, Herts.
1897 Feb. 13	Webb, J. A.	Surveyor to the Rural District Council, Hendon. Great Stanmore.
1905 Oct. 28	Webb, J. H.	Borough Surveyor and Water Engineer, King's Lynn.
1901 Oct. 19	Webster, J. W.	Surveyor to the Urban District Council, Cowes, Isle of Wight.
1905 Jan. 28	Webster, R. A.	Town Engineer, Krugersdorp, Transvaal, South Africa.
1895 May 25 R1901 Aug. 24	Webster, R. J.	District Surveyor, Castleton, Manchester.
1882 Apr. 15	Welburn, W.	Borough Surveyor, Middleton, near Manchester.
1887 June 18 R1903 Feb. 21	Weston, G.	The Limes, Harrow Road, Pinner.
1889 Apr. 13 R1903 Jan. 17	Weston, H. J., Assoc. M. Inst. C.E.	24 Portland Street, Southampton.
P1888 July 12	White, A. E., M. Inst. C.E. (*Member of Council.*)	City Engineer, Hull.
1891 Oct. 17	White, H. V., M. Inst. C.E. I.	County Surveyor, Queen's County, Maryborough.
1900 Mar. 10	White, J. N.	Borough Surveyor, Stalybridge.
1873 May 2	WHITE, W. H., M. Inst. C.E. (*Past President.*)	City Engineer, Oxford.
1899 Mar. 25	Whittell, F. S.	Surveyor to the Urban District Council, Worksop.
1900 Aug. 25	Whyatt, H. G., A. M. Inst. C.E.	Borough Engineer, Great Grimsby.
1889 Feb. 9	Wike, C. F., M. Inst. C.E. (*Vice-President.*)	City Surveyor, Sheffield.
1888 May 12	Wild, G. H.	Surveyor to the Urban District Council, Littleborough, near Manchester.
1896 Apr. 25	Wilding, J.	Surveyor to the Urban District Council, Runcorn.
1905 June 22	Wiles, J. W.	Surveyor to the Urban District Council, Gorton, Lancs.
1884 May 29 R1902 Nov. 8	Wilkinson, J. P., M. Inst. C.E.	301–304 Corn Exchange Chambers, Cathedral Street, Manchester.

Date of Election and Transfer.		
1899 Mar. 25	Wilkinson, M. H.	Surveyor to the Urban District Council, Leyland.
1899 Feb. 25 R1903 Mar. 21	Wilkinson, W.	Ashton House, Hemingbrough, E. Yorks.
1884 Oct. 9 R1885 June 6	Willcox, J. E., Assoc. M. Inst. C.E.	63 Temple Row, Birmingham.
1894 Mar. 3	Williams, H. Dawkin	Surveyor to the Urban District Council, Ogmore and Garrw, Blackmill R.S.O., Bridgend.
1904 May 28	Williams, J.	Surveyor to the Urban District Council, Abercarn, Mon.
1893 July 31	Williams, J. B.	Borough Surveyor, Daventry.
1897 May 15	Williams, M.	Surveyor to the Urban District Council, Bridgend.
1904 Aug. 4	Williamson, W.	City Engineer's Office, Glasgow.
1891 June 25	Willmot, J.	County Surveyor, Warwickshire. 6 Waterloo Street, Birmingham.
1904 Oct. 29	Willoughby, P. R. A., A.M. Inst. C.E.	Surveyor to the Urban District Council, Pontypridd.
1898 June 30	Wilson, A.	County Surveyor, Dumbartonshire.
1887 Sept. 17	Wilson, G.	Surveyor to the Urban District Council, Alnwick.
1873 May 2 R1899 Feb. 25	Wilson, J.	Bankside, Bacup, Lancashire.
1884 May 29	*Wilson, J. B., A.M. Inst. C.E.	Surveyor to the Rural District Council, Cockermouth.
1904 Aug. 23	Wilson, J. R.	Burgh Surveyor, Helensburgh, N.B.
1897 Oct. 16	Winning, D.	Burgh Surveyor, Broughty Ferry, N.B.
1880 Oct. 2	Winship, G., A.M. Inst. C.E.	Borough Surveyor, Abingdon, Berks.
1896 Feb. 22	Winter, O. E., Assoc. M. Inst. C.E.	Borough Surveyor, Hampstead, N.W.
G1900 May 19 TA1902 Jan. 25 T1902 Nov. 8	*Wolfenden, B. J., A.M. Inst. C.E.	Borough Engineer, Bootle.
1880 Feb. 7	Wood, A. R.	Surveyor to the Urban District Council, Tunstall.
1894 Mar. 3	Wood, F. J., A. M. Inst. C.E.	County Surveyor, Sussex East. Lewes.
1898 Apr. 23	Wood, W. E.	Surveyor to the Urban District Council, Church.
1900 Feb. 10	Woods, E. L.	Town Surveyor, Bangor, Co. Down.
1885 Oct. 3 R1903 Feb. 21	Woodbridge, C. A.	Pinner House, Pinner, Middlesex.
1899 May 6	Woodward, F.	Surveyor to the Urban District Council. Stourbridge.
G1900 July 19 T1901 Oct. 19	*Wootton, A. S.	Surveyor, Urban District Council, Bradford-on-Avon.
1897 July 8	*Worrall, E.	Surveyor to the Urban District Council, Stretford, Council Offices, Old Trafford.

Date of Election and Transfer.		
1886 July 8	Worth, J. E., M. Inst. C.E.	District Engineer, London County Council, Spring Gardens, S.W.
G1893 July 13 T1899 Oct. 21 R1904 Dec. 3	*Wright, J. A.	6 Unity Street, Bristol.
1892 May 28	Wynne-Roberts, R. O., M. Inst. C.E.	Water Engineer, Cape Town.
1895 Jan. 19	YABBICOM, T. H., M.Inst. C.E. (*Past President. Member of Council.*)	City Engineer, Bristol.
G1892 July 11 T1892 Sept. 24	*Yates, F. S., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Waterloo, near Liverpool.
1894 June 21	York, H., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, East Barnet Valley. Station Road, New Barnet.
1904 Aug. 26	Young, C.	Burgh Surveyor, Coatbridge, N.B.
1900 May 19	Young, J.	Burgh Surveyor, Ayr.
1899 Dec. 16	Young, T.	Surveyor to the Rural District Council, Sunderland.
1900 May 19	Young, W. P...	Surveyor to the Rural District Council, Wallsall..

TOWNS AND DISTRICTS

REPRESENTED BY MEMBERS OF THE ASSOCIATION.

A.	*signifies*	Abroad.	Met.	*signifies*	Metropolitan District.
Af.	„	African District.	M.	„	Midland District.
E.	„	Eastern District.	N.	„	Northern District.
H.	„	Home District.	S.	„	Scottish District.
Ind.	„	Indian District.	W.N.	„	Welsh District (North).
I.	„	Irish District.	W.S.	„	„ „ (South).
L. & C.	„	Lancashire & Cheshire District.	West.	„	Western District.
			Y.	„	Yorkshire District.

TOWN.	DISTRICT.	NAME.
Abercarn	West.	J. Williams.
Aberdeen	S.	W. Dyack.
Abergavenny	West.	J. Haigh.
Abingdon	H.	G. Winship.
Abram	L. & C.	G. Heaton.
Accrington	L. & C.	W. J. Newton.
Acton	H.	D. J. Ebbetts.
Aldershot	H.	F. C. Uren.
Alnwick	N.	G. Wilson.
Altrincham	L. & C.	J. Stokoe.
Andover	H.	R. W. Knapp.
Annfield Plain	N.	T. J. Trowsdale.
Antrim (County)	I.	J. H. Brett.
Arbroath, N.B.	S.	P. C. Smith.
Argyllshire (County)	S.	M. B. McBeth.
Armagh	I.	J. C. Boyle.
„ (County)	I.	R. H. Dorman.
Ashbourne	M.	W. Stringfellow.
Ashby-de-la-Zouch	M.	S. Turner.
Ashford	H.	W. Terrill.
Ashton-under-Lyne	L. & C.	J. T. Earnshaw.
Ashton-on-Mersey	L. & C.	F. Hutton.
Aston Manor	M.	G. H. Jack.
Atherstone (Rural)	M.	H. J. Coleby.
Atherton	L. & C.	W. Clough.
„	L. & C.	F. H. Grimshaw.
Athlone (County)	I.	C. J. Mulvany.
Audley	M.	T. Bibbey.
Ayr	S.	J. Young.
Ayrshire (County)	S.	A. Stevenson.
Balby with Hexthorpe	Y	G. Gledhill.
Ballymena	I.	H. O'Hara.
Banbury	H.	N. H. Dawson.
Bangor, Co. Down	I.	E. L. Woods.
Barking	H.	C. F. Dawson.

TOWN.	DISTRICT.	NAME.
Barnes	H.	G. B. Tomes.
Barrow-in-Furness	L. & C.	J. W. Smith.
Barry	W.S.	J. C. Pardoe.
Barton-upon-Irwell (Rural)	L. & C.	C. C. Hooley.
Basford (Rural)	M.	S. Maylan.
„ „ (Highways)	M.	G. W. Hawley.
Basingstoke	H.	F. R. Phipps.
Battersea	Met.	T. W. A. Hayward.
Beccles	E.	T. O. Cudbird.
Beckenham	H.	J. A. Angell.
Bedford	H.	N. Greenshields.
Bedford (County)	H.	W. H. Leete.
Belfast	I.	H. A. Cutler.
Belper	M.	T. Fenn.
„ (Rural)	M.	R. C. Cordon.
Benares, India	Ind.	G. E. Hull.
Benwell	N.	W. P. Pattison.
Bermondsey	Met.	R. J. Angel.
Berwick-on-Tweed	S.	R. Dickinson.
Berwickshire (County), N.B.	S.	T. R. Atkinson.
Bethnal Green	Met.	E. E. Finch.
Beverley	Y.	J. G. Smith.
„ (Rural)	Y.	E. Picker.
Bexhill	H.	G. Ball.
Bexley	H.	W. T. Howse.
Biddulph	M.	S. Gibson.
Biggleswade	H.	T. Cockrill.
„ (Rural)	H.	J. O. Jones.
Bilston	M.	J. P. Wakeford.
Bingley	Y.	H. Bottomley.
Birkenhead	L. & C.	C. Brownridge.
Birmingham	M.	J. Price.
Bishop's Castle	M.	A. Hamar.
Bishop's Stortford	H.	R. S. Scott.
Blackburn	L. & C.	W. Stubbs.
Blackpool	L. & C.	J. S. Brodie.
Blackwell (Rural)	M.	H. Silcock.
Bloemfontein, South Africa	Af.	H. F. Peet.
Blyth and Cuckney (Rural)	M.	F. Hopkinson.
Bognor	H.	O. A. Bridges.
Bombay	Ind.	J. Hall.
Bo'ness, N.B.	S.	J. P. Lawrie.
Bootle	L. & C.	B. J. Wolfenden.
Boston, Lincs.	E.	G. E. Clarke.
Bourne (Rural)	E.	A. J. Metcalfe.
Bournemouth	H.	F. W. Lacey.
Brackley	M.	A. A. Green.
Bradford	Y.	J. H. Cox.
Bradford-on-Avon	West.	A. S. Wootton.
Braintree	E.	H. H. Nankivell.
Branksome	West.	S. J. Newman.
Brecon	W.	H. Ll. Griffiths.
Brentford	H.	N. Parr.
Brentwood	E.	J. E. Fothergill.
Bridgend	W.S.	M. Williams.
Bridgwater	West.	F. Parr.
Bridgwater (Rural)	West.	W. A. Collins.
Bridlington	Y.	E. R. Matthews.
„ (Rural)	Y.	S. Dyer.
Brierfield	L. & C.	B. Halstead.

TOWN.	DISTRICT.	NAME.
Brierley Hill	M.	J. L. Harpur.
Brighouse	Y.	S. S. Haywood.
Brisbane, Queensland	A.	J. Kemp.
Bristol	West.	T. H. Yabbicom.
Briton Ferry	W.S.	H. A. Clarke.
Broadstairs	H.	H. Hurd.
Bromyard	M.	J. D. Barrs.
Broughty Ferry, N.B.	S.	D. Winning.
Brownhills	M.	W. B. Chancellor.
Brynmawr	W.S.	D. W. Slocombe.
Buckhurst Hill	E.	H. Tooley.
Buckingham	H.	J. Smith.
„ (County)	H.	R. J. Thomas.
Bucklow (Rural)	L. & C.	J. McD. McKenzie.
Burnham	West.	W. H. Chowins.
Burnley	L. & C.	G. H. Pickles.
„ (Rural)	L. & C.	S. Edmondson.
Burslem	M.	F. Bettany.
Burton-on-Trent	M.	G. T. Lynam.
Bury	L. & C.	A. W. Bradley.
Bury St. Edmunds	E.	W. D. Harding.
Buxton	M.	W. H. Grieves.
Caerphilly	W.S.	A. O. Harpur.
Camberwell	Met.	W. Oxtoby.
Cannock, Staffs	M.	J. S. Hendry.
Canterbury	H.	A. C. Turley.
Cape Town, South Africa	Af.	J. Cook.
Cardiff	W.S.	W. Harpur.
Carlisle	N.	H. C. Marks.
Carlton	M.	J. C. Haller.
Carmarthen	W.S.	F. J. Finglah.
Carnarvonshire (County)	W.N.	E. Evans.
„	W.N.	E. Hall.
Castleford	Y.	W. Green.
Chatham	H.	C. Day.
Chelmsford	E.	C. Brown.
„ (Rural)	E.	J. Dewhirst.
Chelsea	Met.	T. W. E. Higgens.
Cheltenham	West.	J. S. Pickering.
Cheriton	H.	F. Feather.
Chertsey	H.	J. F. Stow.
Chesham	H.	P. C. Dormer.
Cheshire (County)	L. & C.	H. F. Bull.
Cheshunt	H.	R. H. Jeffes.
Chester	L. & C.	I. M. Jones.
Chesterfield	M.	V. Smith.
„ (Rural)	M.	E. Lines.
Chesterton	E.	J. D. Bland.
„ (Rural)	E.	J. Dunn.
Chichester	H.	I. Pym-Jones.
Chippenham	West.	A. E. Adams.
Chiswick	H.	J. Barclay.
Chorley	L. & C.	W. Leigh.
Christchurch	H.	E. I. Legg.
Church	L. & C.	W. E. Wood.
Clayton-le-Moors	L. & C.	A. Dodgeon.

TOWN.	DISTRICT.	NAME.
Cleckheaton	Y.	C. Lund.
Cleethorpes	E.	E. Rushton.
Coalville	M.	L. L. Baldwin.
Coatbridge, N.B.	S.	C. Young.
Cockermouth	N.	F. O. C. Nash.
Cockermouth (Rural)	N.	J. B. Wilson.
Colchester	E.	H. Goodyear.
Colne	L. & C.	T. H. Hartley.
Colombo, Ceylon	Ind.	F. A. Cooper.
„ „	Ind.	R. Skelton.
Colwyn Bay	W.N.	W. Jones.
Congleton	L. & C.	R. Burslam.
Consett	N.	W. S. Shell.
Conway (Rural)	W.N.	T. B. Farrington.
Cork	I.	J. F. Delany.
Cork (County), West	I.	R. W. Longfield.
„ „ South	I.	S. A. Kirkby.
Cottingham	Y.	J. H. Hanson.
Cowes, Isle of Wight	H.	J. W. Webster.
Cowpen	N.	R. Grieves.
Crewe	L. & C.	G. Eaton-Shore.
Crieff, N.B.	S.	G. D. Mackie.
Cromer	E.	A. F. Scott.
Croydon	H.	G. F. Carter.
„ (Highways)	H.	E. F. Morgan.
„ (Rural)	H.	R. M. Chart.
Cumberland (County)	N.	G. J. Bell.
Cupar (Fife) (County)	S.	T. Aitken.
Dartford	H.	T. E. Tiffen.
Dartmouth	West.	A. Smith.
Daventry	M.	J. B. Williams.
Darwen	L. & C.	R. W. Smith-Saville.
Deal	H.	T. C. Golder.
Delhi	Ind.	T. Salkield.
Denton	L. & C.	G. H. Newton.
Derby	M.	J. Ward.
„ (County)	M.	J. S. Story.
Desborough	M.	D. J. Diver.
Devon (County)	West.	W. Ingham.
Dewsbury	Y.	H Dearden.
Doncaster	Y.	W. H. R. Crabtree.
Doncaster (Rural) (Highways)	Y.	W. Crabtree.
Dorchester	West.	G. J. Hunt.
Dorking	H.	G. S. Mathews.
„ (Rural)	H.	W. Rapley.
Dover	H.	H. E. Stilgoe.
Down (County)	I.	J. Heron.
Driffield (Rural)	Y.	T. C. Beaumont.
Droylsden	L. & C.	C. Hall.
Drumlisden, N.B.	S.	J. S. Bruce.
Dublin	I.	S. Harty.
„ (County)	I.	W. Collen.
Dudley	M.	J. Gammage.
Dukinfield	L. & C.	S. Hague.
Dumbartonshire (County)	S.	A. Wilson.
Dunfermline (County)	S.	D. MacKenzie.
Dunstable	M.	G. Simcox.
Durham (Rural)	N.	G. Gregson.

TOWN.	DISTRICT.	NAME.
Ealing	H.	C. Jones.
East Barnet Valley	H.	H. York.
East Ham	H.	A. H. Campbell.
East Molesey	H.	J. Stevenson.
East Retford (Rural)	M.	T. Henry.
East Stow (Rural)	E.	G. F. P. Harrison.
Eastbourne	H.	A. E. Prescott.
Ebbw Vale	West.	T. J. Thomas.
Edinburgh, N.B.	S.	J. Massie.
Elgin, N.B.	S.	A. A. Turriff.
Enfield	H.	R. Collins.
Enniskillen (County)	I.	J. P. Burkitt.
Epsom	H.	E. R. Capon.
Erdington	M.	H. H. Humphries.
Erith	H.	H. Hind.
Eston	Y.	C. McDermid.
Eton (Rural)	H.	R. Hallam.
„ „ (Highways)	H.	A. Gladwell.
Evesham	M.	R. C. Mawson.
Exeter	West.	T. Moulding.
Exmouth	West.	S. Hutton.
Falmouth	West.	W. H. Tressider.
Falkirk, N.B.	S.	D. Ronald.
Fareham	H.	W Butler.
Farnborough	H.	J. E. Hargreaves.
Farnham	H.	R. W. Cass.
Faversham	H.	S. P. Andrews.
Fenny Stratford	H.	J. Chadwick.
Finchley	H.	C. J. Jenkin.
Finsbury	Met.	P. G. Killick.
Flintshire (County)	W.N.	S. Evans.
Folkestone	H.	A. E. Nichols.
Foot's Cray	H.	W. A. Farnham.
Friern Barnet	H.	E. J. Reynolds
Frimley	H.	T. C. Jones.
Frinton-on-Sea	E.	E. M. Bate.
Frome	West.	F. W. Jones.
Gainsborough	E.	S. W. Parker.
Galway (County), West	I.	J. Perry.
„ „ East	I.	J. Smith.
Gateshead	N.	N. P. Pattinson.
Gillingham	H.	J. L. Redfern.
Glamorgan (County)	W.S.	T. L. Edwards.
Glasgow, N.B.	S.	A. B. McDonald.
Glasgow, N B.	S.	T. Nisbet.
Glastonbury	West.	G. Alves.
Gloucester	West.	R. Read.
„ (County)	West.	R. Phillips.
Glyncorrwg	W S.	W. P. Jones.
Godalming	H.	J. H. Norris.
Godstone (Rural)	H.	J. George-Powell.
Goole	Y.	E. H. Barber.
Gorton	L. & C.	J. W. Wiles
Gosforth	N.	G. Nelson
Gosport and Alverstoke	H.	H. Frost.
Govan, N.B.	S.	F. G. Holmes.
Grantham	E.	F. J. Morris.

TOWN.	DISTRICT.	NAME.
Gravesend	H.	F. T. Grant.
Grays Thurrock	H.	A. C. James.
Great Crosby	L. & C.	W. Hall.
Great Grimsby	E.	H. G. Whyatt.
Great Yarmouth	E.	J. W. Cockrill.
Greenock, N.B.	S.	A. J. Turnbull.
Grey County, New Zealand	A.	J. Higgins.
Greymouth, New Zealand	A.	E. I. Lord.
Guernsey	H.	T. J. Guilbert.
Guildford	H.	C. G. Mason.
„ (Rural)	H.	J Anstee.
Hackney	Met.	N. Scorgie.
Hadham and Stansted	H.	E. T. Watts.
Hale	L. & C.	F. Lobley.
Halifax (Rural)	Y.	F. Gordon.
Hamilton, N.B.	S.	W. H. Purdie.
Hammersmith	Met.	H. Mair.
Hampstead	Met.	O. E. Winter.
Hampton-on-Thames	H.	S. H. Chambers.
Hampton Wick	H.	J. N. Horsfield.
Handsworth	M.	H. Richardson.
Hanley	M.	J. Lobley.
Hants (County)	H.	W. J. Taylor.
Hanwell	H.	S. W. J. Barnes.
Harrow	H.	J. P. Bennetts.
Harwich	E.	H. Ditcham.
Haslingden	L. & C.	J. S. Green.
Hastings	H.	P. H. Palmer.
Haverhill	E.	F. W. Knewstubb.
Hawick, N.B.	S.	Chas. Brown.
Hayes	H.	C. C. Gray.
Heckmondwike	Y.	J. Saville.
Helensburgh, N.B.	S.	J. R. Wilson.
Hemel Hempstead	M.	W. R. Locke.
Hendon	H.	S. S. Grimley.
„ (Rural)	H.	J. A. Webb.
Hengoed (Rural)	W.S.	J. P. Jones.
Hereford	M.	J. Parker.
„ (County)	M.	A. Dryland.
Herne Bay	H.	F. W. J. Palmer.
Hertford	H.	J. H. Jevons.
Heysham	L. & C.	H. Miller.
Heywood	L. & C.	J. A. Settle.
High Wycombe	H.	T. J. Rushbrooke.
Hinckley	M.	E. H. Crump.
Hitchin	H.	A. T. Blood.
Hobson County, N.Z.	A.	H. Hammond.
Holyhead	W.N.	A. Asquith.
Hornsea	Y.	W. E. Warburton.
Hornsey	H.	E. J. Lovegrove.
Horsforth	Y.	R. R. Jones.
Horsham	H.	R. Renwick.
Hove	H.	H. H. Scott.
Howrah, Bengal	Ind.	A. Hale.
Hoylake and West Kirby	L. & C.	R. W. Fraser.
Hoyland Nether	Y.	H. G. Keywood.
Huddersfield	Y.	K. F. Campbell.
„ (Gas)	Y.	E. A. Harman.
Hull	Y.	A. E. White.

TOWN.	DISTRICT.	NAME.
Huntingdon (County)	M.	H. J. G. Leete.
Hyde	L. & C.	J. Mitchell.
Hythe	H.	Chris. Jones.
Ilford	E.	H. Shaw.
Ilfracombe	West.	O. M. Prouse.
Inverness	S.	T. H. Scott.
Ipswich	E.	E. Buckham.
Irlam	L. & C.	G. H. Kay.
Ipswich, Queensland	A.	T. Kirk.
Isle of Ely, North (County)	E.	H. F. Simpson.
Isle of Thanet (Rural)	H.	F. T. Elliott.
Islington	Met.	J. P. Barber.
Itchen	H.	T. A. Collingwood.
Johannesburg	Af.	A. P. Lambert.
Kearsley	L. & C.	H. Nuttall.
Keighley	Y.	W. H. Hopkinson.
Kendal	N.	R. H. Clucas.
Kenilworth	M.	S. Douglas.
Kensington	Met.	W. Weaver.
Kent (County)	H.	H. P. Maybury.
Kesteven (County)	E.	W. B. Purser.
Keswick	N.	W. Hodgson.
Kettering	M.	T. R. Smith.
Keynsham (Rural)	West.	H. M. Bennett.
Kidderminster (Rural)	M.	A. Comber.
Kilkenny (County)	I.	A. M. Burden.
Kilmarnock, N.B.	S.	R. Blackwood.
King's Lynn	E.	J. H. Webb.
King's Norton	M.	A. W. Cross.
Kingston (Highways)	H.	A. J. Henderson.
Kingston, Jamaica	A.	C. V. Abrahams.
Kirkcaldy	S.	J. L. Lumsden.
Kirkcudbrightshire (County)	S.	J. D. Smith.
Kroonstad, O.R.C.	Af.	F. Brown.
Krugersdorp, Transvaal	Af.	R. A. Webster.
Lambeth	Met.	H. C. J. Edwards.
Lancashire (County)	L. & C.	W. H. Schofield.
Lancaster	L. & C.	J. C. Mount.
Lanchester (Rural) (Highways)	N.	W. Cumming.
Leatherhead	H.	J. E. Smales.
Leeds	Y.	W. T. Lancashire.
Leeds (Sewerage)	Y.	G. A. Hart.
Leek	M.	W. E. Beacham.
Leicester	M.	E. G. Mawbey.
,, (County)	M.	S. P. Pick.
Leigh	L. & C.	T. Hunter.
,, (Rural)	L. & C.	T. W. B. Gent.
Leigh-on-Sea	E.	W. J. Petch.
Leighton Buzzard	H.	J. Stewart.
Leith, N.B.	S.	J. R. Findlay.
Leitrim (County)	I.	E. O'N. Clarke.
Levenshulme	L. & C.	J. Jephson.
Lewes	H.	D. Roberts.
Leyland	L. & C.	W. H. Wilkinson.
Leyton	H.	W. Dawson.

TOWN.	DISTRICT.	NAME.
Limehurst (Rural)	L. & C.	H. H. Turner.
Limerick (County)	I.	J. Horan.
Lincoln	E.	R. A. MacBrair.
„ (County)	E.	J. Thropp.
Litherland	L. & C.	A. H. Carter.
Littleborough	L. & C.	G. H. Wild.
Littlehampton	H.	H. Howard.
Little Woolton	L. & C.	R. Simmons.
Liverpool	L. & C.	J. A. Brodie.
Llandaff (Rural) (Highways)	W.S.	J. Holden.
Llandudno	W.N.	E. P. Stephenson.
Llanelly	W.S.	G. Watkeys.
Llantrissant (Rural)	W.S.	G. S. Morgan.
Loftus	Y.	T. H. Tarbit.
London	Met.	F. Sumner.
„ (County)	Met.	M. Fitzmaurice.
Londonderry	I.	W. J. Robinson.
Long Crendon	M.	E. Parry.
Longford (County)	I.	J. W. Gunnis.
Longton	M.	J. W. Wardle.
Loughborough	M.	A. H. Walker.
Louth (County)	I.	P. J. Lynam.
Lower Bebington	L. & C.	H. W. Corrie.
Lower Hutt, N.Z.	A.	T. Ward.
Lowestoft	E.	G. H. Hamby.
Lucknow (United Provinces)	Ind.	H. Lane Brown.
Ludlow	West.	J. A. Spreckley.
Lurgan	I.	H. Shillington.
Lymington	H.	F. H. Parr.
Lytham	L. & C.	A. J. Price.
Macclesfield (Rural)	L. & C.	J. Thorpe.
Maesteg	W.S.	J. Humphreys.
Maidstone	H.	T. F. Bunting.
„ (Rural)	H.	J. S. Killick.
Maldon	E.	T. R. Swales.
Manchester	L. & C.	T. De C. Meade.
Mansfield	M.	R. F. Vallance.
Mansfield Woodhouse	M.	F. P. Cook.
Margam, Port Talbot	W.S.	J. Cox.
Margate	H.	E. A. Borg.
Market Harborough	M.	H. G. Coales.
Marylebone	Met.	J. A. P. Waddington.
Matlock	M.	J. Diggle.
Matlock Bath	M.	W. Jaffrey.
Maxwelltown, N.B.	S.	J. McL. Bowie.
Melbourne	A.	W. Thwaites.
Melford (Rural)	E.	W. Carver.
Melton Mowbray	M.	E. Jeeves.
Merthyr Tydvil	W.S.	T. F Harvey.
Methley	Y.	T. W. Nichols.
Mexborough	Y.	G. F. Carter.
Middlesbrough	Y.	F. Baker.
Middlesex (County)	H.	H. T. Wakelam.
Middleton	L. & C.	W. Welburn.
Midhurst (Rural)	H.	A. G. Gibbs.
Midsomer Norton	West.	W. F. Bird.
Milton-next-Sittingbourne	H.	W. R. Warlow.
Minehead	West.	J. H. Wooton-Smith.

TOWN.	DISTRICT.	NAME.
Monmouthshire (County)	West.	W. Tanner.
Montgomery	W.N.	W. P. Hole.
Morley	Y.	W. E. Putman.
Morpeth (Rural) (Highways)	N.	J. M. MacGregor.
Musselburgh, N.B.	S.	G. Landale.
Nantyglo and Blaina	West.	W. J. Davies.
Neath	W.S.	D. M. Jenkins.
„ (Rural)	W.S.	W. E. C. Thomas.
Nelson	L. & C.	B. Ball.
Neston	L. & C.	C. E. Senior.
New Malden	H.	T. B Simmonds.
New Swindon	H.	H. J. Hamp.
Newark	M.	G. Sheppard.
„ (Rural)	M.	R. Oakden.
Newburn-on-Tyne	N.	T. Gregory.
Newbury	H.	S. J. L. Vincent.
Newcastle-on-Tyne	N.	F. J. Edge.
Newhaven	H.	F. J. Rayner.
Newmarket	E.	J. W. Metcalf.
Newport, Mon.	West.	R. H. Haynes.
Newton Abbot	West.	L. Stevens.
Newtown St. Boswells, N.B.	S.	G. Monteath.
Northampton	M.	A. Fidler.
Northumberland (County)	N.	J. A. Bean.
Northwich	L. & C.	J. Brooke.
Norwich	E.	A. E. Collins.
Nottingham	M.	A. Brown.
„ (County)	M.	E. P. Hooley.
Nuneaton	M.	F. C. Cook.
Oakham (Rural)	E.	C. W. Maudsley.
Oakworth	Y.	J. Spencer.
Ogmore and Garrw	W.S.	H. D. Williams.
Oldbury	M.	T. H. Shipton.
Oldham	L. & C.	S. A. Pickering.
Oswestry	M.	G. W. Lacey.
Otley	Y.	J. E. Sharp.
Oxford	H.	W. H. White.
Oxfordshire (County)	H.	S. Stallard.
Oystermouth	W.S.	M. Hoskins.
Paddington	Met.	E. B. Newton.
Padiham	L. & C.	J. Gregson.
Paignton	West.	C. O. Baines.
Paisley, N.B.	S.	J. Lee.
Partick, N.B.	S.	J. Bryce.
Peebles (County)	S.	R. S. Anderson.
Pemberton	L. & C.	G. Heaton.
Penarth	W.S.	E. I. Evans.
Penge	H.	H. W. Longdin.
Penrith	N.	J. J. Knewstubb.
Perth, N.B.	S.	R. McKillop.
Perth, West Australia	A.	H. T. Haynes.

TOWN.	DISTRICT.	NAME.
Peterborough	M.	J. W. Walshaw.
Plymouth	West.	J. Paton.
Pokesdown	H.	E. W. Ingamells.
Pollokshaws, N.B.	S.	D. Burns.
Pontardawe (Rural)	W.S.	J. Morgan.
Pontefract	Y.	J. E. Pickard.
Pontypridd	W.S.	P. R. A. Willoughby.
Poole	West.	J. Elford.
Port Elizabeth, South Africa	Af.	A. S. Butterworth.
Port Glasgow, N.B.	S.	J. Murray.
Portishead	West.	F. H. Smith.
Portland	West.	R. S. Henshaw.
Portslade-by-Sea	H.	A. T. Allen.
Portsmouth	H.	P. Murch.
Prahran, Victoria	A.	W. Calder.
Prestwich	L. & C.	W. Nuttall.
Queen's County	I.	H. V. White.
Queenstown, South Africa	Af.	W. A. Palliser.
Ramsgate	H.	T. G. Taylor.
Rawmarsh	Y.	J. Bourne.
Rawtenstall	L. & C.	J. Johnston.
Redcar	Y.	J. Howcroft.
Redditch	M.	B. Perrins.
Reigate	H.	F. T. Clayton.
Renfrewshire (County), N.B.	S.	J. Murray.
Retford	M.	J. D. Kennedy.
Rhondda	W.S.	W. J. Jones.
Rhymney	West.	W. L. Marks.
Richmond, Surrey	H.	J. H. Brierley.
Rochdale	L. & C.	S. S. Platt.
Rochester	H.	W. Banks.
Rochford (Rural)	H.	H. T. Sidwell.
Rotherham	Y.	G. Jennings.
Rowley Regis	M.	W. H. Brettell.
Rugeley	M.	W. E. Rogers.
Runcorn	L. & C.	J. Wilding.
„ (Rural)	L. & C.	W. Diggle.
Rushden	M.	W. B. Madin.
Rutherglen, N.B.	S.	S. McBride.
Rutland (County)	E.	J. Richardson.
Ryton-on-Tyne	N.	J. P. Dalton.
Saffron Walden	E.	A. H. Forbes.
St. Albans	H.	G. Ford.
St. Andrews, N.B.	S.	W. Watson.
St. Helen's, Lancs.	L. & C.	G. J. C. Broom.
„ Isle of Wight	H.	J. I. Barton.
St. Pancras	Met.	W. N. Blair.
Sale	L. & C.	W. Holt.
Salford	L. & C.	J. Corbett.
Saltburn-by-the-Sea	Y.	G. S. L. Bains.
Sandgate	H.	A. R. Bowles.

TOWN.	DISTRICT.	NAME.
Scarborough	Y.	J. A. Iveson
Scarborough	Y.	H. W. Smith.
Sedgfield, Co. Durham	N.	J. Stones.
Selkirk, N.B.	S.	J. Pritty.
Sevenoaks	H.	S. Towlson.
Shanghai, China	A.	C. Mayne.
Shanklin	H.	E. C. Cooper.
Sheffield	Y.	C. F. Wike.
Shepton Mallet	West.	D. Hinchcliff.
Sherborne	West.	T. Farrall.
Shoreditch	Met.	J. R. Dixon.
Shrewsbury	M.	W. C. Eddowes.
Shropshire (County)	M.	A. T. Davis.
Singapore	A	R. Peirce.
Skelton-in-Cleveland	Y.	W. P. Robinson.
Skipton	Y.	J. Mallinson.
„ (Rural)	Y.	A. Rodwell.
Sleaford	E.	J. Clare.
„ (Rural)	E.	A. Brooke.
Slough	H.	W. W. Cooper.
Smallthorne	M.	J. Deane.
Smethwick	M.	C. J. Fox-Allin.
Solihull (Rural)	M.	A. E. Currall.
Soothill Upper	Y.	J. Blackburn.
South Shields	N.	S. E. Burgess.
Southall Norwood	H.	R. Brown.
Southampton	H.	J. A. Crowther.
Southend-on-Sea	H.	E. J. Elford.
Southgate	H.	C. G. Lawson.
Southowram	Y.	W. H. D. Horsfall.
Southport	L. & C.	R. P. Hirst.
Southwark	Met.	A. Harrison.
Southwick	H.	G. W. Warr.
Southwick-on-Wear	N.	W. B. Thomas.
Spalding (Rural)	E.	T. J. Peacock.
Spilsby (Rural)	E.	T. A. Busbridge.
Stafford	M.	W. Blackshaw.
„ (County) (Highways)	M.	J. Moncur.
Staines	H.	E. J. Barrett.
„ (Rural)	H.	G. W. Manning.
Stalybridge	L. & C.	J. N. White.
Stamford	E.	F. R. Ryman.
Stepney	Met.	M. W. Jameson.
Stirling	S.	A. H. Goudie.
Stirlingshire (Highways)	S.	R. M. Reid.
Stockport	L. & C.	J. Atkinson.
Stockton-on-Tees	N.	M. H. Sykes.
Stoke-on-Trent	M.	A. Burton.
Stoke Newington	Met.	W. F. Loveday.
Stone	M.	A. R. Ridout.
Stourbridge	M.	F. Woodward.
Stratford-on-Avon	M.	R. Dixon.
Stretford	L. & C.	E. Worrall.
Strood (Rural)	H.	W. Brooke.
Stroud	West.	G. P. Milnes.
Sudbury, Suffolk	E.	W. E. Bush.
Suffolk (County), East	E.	H. Miller.
Sunbury-on-Thames	H.	H. F. Coales.
Sunderland (Rural)	N.	T. Young.
Surrey (County)	H.	F. G. Howell.

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TOWN.	DISTRICT.	NAME.
Sussex (County), East	H.	F. J. Wood.
Sutton	H.	C. C. Smith.
Sutton Coldfield	M.	W. A. H. Clarry.
Sutton-in-Ashfield	M.	W. Burn.
Swadlincote	M.	T. Kidd.
Swaffham	E.	F. Hall Smith.
Swanage	West.	J. S. Senior.
Swansea	W.S.	G. Bell.
Swinton	L. & C.	H. Entwisle.
Sydney, New South Wales	A.	J. M. Smail.
Tadcaster (Rural)	Y.	T. Scott.
Tamworth	M.	F. E. G. Bradshaw.
„ (Rural)	M.	H. J. Clarson.
Tanfield	N.	R. Heslop.
Taunton (Rural)	West.	T. Goldsworthy-Crump.
Teddington	H.	M. Hainsworth.
Teignmouth	West.	C. T. Gettings.
Tenbury (Rural)	M.	R. W. Jarvis.
Tewkesbury	West.	W. Ridler.
Thornhill	Y.	A. Rothera.
Tientsin, China	A.	A.W.H. Bellingham.
Tipperary (County), South	I.	E. A. Hackett.
Tipton	M.	W. H. Jukes.
Tiverton	West.	J. Siddalls.
Tokio Fu, Japan	A.	R. Hara.
Tonbridge	H.	W. L. Bradley.
„ (Rural)	H.	F. Harris.
Toowong, Queensland	A.	W. E. Irving.
Tottenham	H.	W. H. Prescott.
Tottington	L. & C.	L. Kenyon.
Towyn	W.N.	R. P. Morgan.
Trowbridge	West.	H. G. N. Lailey.
Truro	West.	M. Lea.
Tunbridge Wells	H.	W. H. Maxwell.
Tunstall	M.	A. R. Wood.
Turton	L. & C.	V. Laithwaite.
Twickenham	H.	F. W. Pearce.
Tyldesley	L. & C.	J. B. Smith.
Tynemouth	N.	J. F. Smillie.
Tyrone (County), North	I.	F. J. Lynam.
„ „ South	I.	J. W. Leebody.
Urmston	L. & C.	J. Heath.
Uxbridge (Rural) (Highways)	H.	E. Birks.
„ (Rural)	H.	J. F. Stow.
Wakefield	Y.	R. Porter.
„ (Rural)	Y.	F. Massie.
Wallasey	L. & C.	W. H. Travers.
Walsall	M.	R. H. Middleton.
„ (Rural)	M.	W. P. Young.
Waltham Cross	E.	W. T. Streather.
Walthamstow	H.	E. Morley.

TOWN.	DISTRICT.	NAME.
Wandsworth (Eastern)	Met.	H. J. Marten.
„ (Western)	Met.	P. Dodd.
Wanstead	H.	J. T. Bressey.
Wantage	H.	W. Hanson.
Warminster	West.	C. H. Lawton.
Warrnambool, Melbourne	A.	J. C. Ross.
Warwickshire (County)	M.	J. Willmot.
Waterford	I.	M. J. Fleming.
„ (County)	I.	W. E. L. Duffin.
Waterloo	L. & C.	F. S. Yates.
Watford	H.	D. Waterhouse.
Wath-upon-Dearne	Y.	H. C. Poole.
Wealdstone	H.	H. Walker.
Wembley	H.	C. R. W. Chapman.
West Bromwich	M.	A. D. Greatorex.
West Hartlepool	N.	N. F. Dennis.
West Malling (Rural)	H.	J. Marshall.
Westminster	Met.	J. W. Bradley.
Weston-super-Mare	West.	H. Nettleton.
Weymouth and Melcombe Regis	West.	W. B. Morgan.
Whitchurch	M.	M. Sowden.
Whitehaven	N.	E. E. Stiven.
Wicklow	I.	J. Pansing.
Widnes	L. & C.	J. S. Sinclair.
Willenhall	M.	T. E. Fellows.
Willesden	H.	O. C. Robson.
Willington Quay	N.	J. F. Davidson.
Wilmslow	L. & C.	A. S. Cartwright.
Wimbledon	H.	C. H. Cooper.
Winchester	H.	W. V. Anderson.
„ (Rural)	H.	G. E. Carter.
Windermere	L. & C.	C. E. Hines.
Windsor	H.	E. A. Stickland.
Winton	H.	J. H. Scott.
Wisbech	E.	A. H. Plowright.
Wokingham	M.	C. W. Marks.
Wolverhampton	M.	G. Green.
Wombwell	Y.	J. W. Harrison.
Wood Green	H.	C. J. Gunyon.
Woodford	E.	W. Farrington.
Worcester	M.	T. Caink.
„ (County)	M.	J. H. Garrett.
Worksop	M.	F. S. Whittell.
Worthing	H.	F. Roberts.
Wortley (Rural)	Y.	G. E. Beaumont.
Wrexham (Rural)	W.N.	J. P. Evans.
York	Y.	A. Creer.
Yorkshire, East Riding	Y.	A. Beaumont.
„ North Riding	Y.	W. G. Bryning.

ASSOCIATES.

* *Those Associates against whose names a star is placed have obtained the certificate of the Association.*

G *signifies elected as Graduate.*
TA *transferred to Associate Class.*

Date of Election and Transfer.		
1901 Oct. 19	Ashbee, W.	Divisional Surveyor, Middlesex C.C. Briarside, Hanwell, W.
1904 Sept. 17	Bell, C. D., B.Sc. (*Vict.*)	Borough Engineer's Office, Barrow-in-Furness.
1902 Jan. 25	*Bell, L. M., M. Inst. C.E.	Municipal Engineer, Penang, S.S.
G1897 July 31 TA1901 Oct. 19	*Bentley, J. H., A. M. Inst. C.E.	Chief Engineering Assistant, Town Hall, Oldham.
G1904 May 28 TA1905 June 22	*Berridge, H. M. K.	Assistant Surveyor, Council Offices, Long Eaton.
G1898 June 30 TA1901 Oct. 19	*Best, H. Storr	Assistant Engineer, Council Offices, Beckenham, S.E.
G1893 June 24 TA1902 Nov. 8	*Birch, J.	Deputy Surveyor, Public Offices, East Ham.
1903 Jan. 17	*Booth, E. W.	Engineering Assistant, Town Hall, Croydon.
G1899 June 10 TA1905 Jan. 28	*Bradshaw, A. S.	Deputy Borough Engineer, Bedford.
G1898 June 30 TA1903 June 25	*Briscoe, J. T.	Deputy Engineer, Council Offices, Enfield.
1903 July 25	*Bromly, A., A.M. Inst. C.E.	Assistant Engineer, Town Hall, Croydon.
1902 Jan. 25	Brookes, A. E.	Assistant County Surveyor, Worcester C.C. Breedon Cross, King's Norton, Birmingham.
1902 Jan. 25	Brown, H. A.	Assistant Borough Surveyor, Town Hall, Fulham, S.W.
1904 May 28	*Burton, W. E. H.	Chief Engineering Assistant, County Architect's Office, Wakefield.
1904 Sept. 1	Carson, W. H.	City Engineer's Office, Glasgow, N.B.
1904 May 28	Carter, E. W. A.	Assistant City Surveyor, Guildhall, Gloucester.
G1890 Sept. 13 TA1902 Sept. 6	*Catchpole, H.	Chief Assistant Engineer, Council Offices, Finchley.
G1895 May 25 TA1902 May 10	*Clark, A. H. F.	District Engineer, P.W.D., Ceylon.
G1894 July 7 TA1904 Sept. 17	*Claypoole, A. H., A.M. Inst. C.E.	District Surveyor, 63 Queen Square, Bristol.

Date of Election and Transfer.		
G1898 Dec. 17 TA1902 Mar. 22	*Clews, C. A.	Engineering Assistant, Borough Surveyor's Office, Derby.
G1899 June 29 TA1902 Jan. 25	*Collinge, T. P., A.M. Inst. C.E.	Deputy City Engineer, Town Hall, Carlisle.
1905 May 27	Collins, H.	Deputy City Engineer, Norwich.
G1897 Feb. 13 TA1901 Oct. 19	*Collis-Adamson, A. C.	Engineering Assistant, Council Offices, Hornsey, N.
1904 Oct. 11	Connor, C.	c/o W. Kennedy, Ltd., 25 Victoria Street, Westminster.
1903 May 16	Cooke, J. E.	Assistant Borough Engineer, Town Hall, Islington.
G1900 May 19 TA1901 Oct. 19	*Coombs, C. A.	Engineering Assistant, Town Hall, Burton-on-Trent.
G1899 Oct. 21 TA1902 Nov. 8	*Cowan, G.	District Surveyor, Town Hall, Portsmouth.
G1901 Aug. 24 TA1901 Oct. 19	*Cox, A. L.	City Surveyor's Office, Manchester.
1905 Mar. 4	*Cox, C. L.	Assistant Surveyor, Urban District Council, Gosport.
1902 Jan. 25	Crook, W. E.	Chief Engineering Assistant, Middlesex C.C. Guildhall, Westminster.
1901 Oct. 19	*Croxford, C. H.	Chief Engineering Assistant, Town Hall, Wood Green, N.
G1903 Dec. 12 TA1905 May 27	*Debney, W., A.M. Inst. C.E.	Borough Engineer's Office, Birkenhead.
1904 Aug. 19	De Kretser, H. K.	District Engineer, P. W. D., Colombo, Ceylon.
G1898 Oct. 15 TA1904 Feb. 27	*Dickinson, A. J.	Council House, Birmingham.
G1891 Sept. 12 TA1902 Sept. 6	*Dolamore, F. P.	Deputy Borough Engineer, Bournemouth.
1904 Aug. 12	Donald, R. B., A.M.Inst.C.E.	c/o Borough Engineer, Huddersfield.
G1899 June 29 TA1905 June 22	*Dyer, R. H.	Assistant Borough Engineer, Southend-on-Sea.
G1898 Dec. 17 TA1901 Dec. 7	*Ellison, D.	Deputy Borough Engineer, West Bromwich.
G1898 Feb. 19 TA1902 Jan. 25	*Endsor, H. A.	Surveyor, Rural District Council, Keynsham, Bristol.
1904 Aug. 27	Forbes, W.	Burgh Engineer's Office, Edinburgh, N.B.
G1899 Oct. 21 TA1903 July 25	*Foster, H. H.	Assistant Surveyor, Borough Surveyor's Office, Wandsworth. 215 High Rd., Balham.
G1901 June 8 TA1901 Oct. 19	*Fowlds, W., A.M. Inst. C.E.	Chief Assistant, Borough Engineer's Office, Keighley.
G1896 Jan. 18 TA1904 May 28	*Fox, S. F. L., A.M. Inst. C.E.	Deputy Borough Engineer, Newport, Mon.

Date of Election and Transfer.		
G1901 May 11 TA1902 Jan. 25	*Gair, J.	Assistant Borough Surveyor, Town Hall, Hammersmith, W.
1903 Mar. 21	Galbraith, A. R., A.M.Inst. C.E.I.	District Surveyor, Town Hall, Portsmouth.
1905 June 22	*Gammage, E. J.	Borough Surveyor's Office, Dudley.
G1898 Jan. 15 TA1903 Jan. 17	*Godfrey, C. H., A.M.Inst.C.E.	Assistant Engineer, Municipal Offices, Shanghai.
1905 June 22	*Goode, W. J.	Divisional Surveyor, Shirehall, Shrewsbury.
G1899 Dec. 16 TA1902 May 10	*Goodfellow, H.	Chief Engineering Assistant, Town Hall, Southport.
G1894 Jan. 13 TA1902 July 10	*Gordon, J., A.M. Inst. C.E.	Assistant Burgh Surveyor, Aberdeen, N.B.
1903 July 25	Gray, A. R.	Engineering Assistant, Council House, Birmingham.
G1893 Jan. 14 TA1901 Oct. 19	*Greenwood, J. P., A.M. Inst. C.E.	Deputy Borough Surveyor, Town Hall, Burnley.
1904 Aug. 9	Greig, J. M. M.	7 Hartington Place, Carlisle.

1902 Mar. 22	Hadfield, W. J.	Deputy City Surveyor, Town Hall, Sheffield.
G1897 June 19 TA1901 Oct. 19	*Haigh, W. H., A.M. Inst.C.E.	Chief Engineering Assistant, Town Hall, Cardiff.
1903 June 6	Harding, H. W.	Chief Engineering Assistant, City Engineer's Office, Bristol.
G1899 Oct. 21 TA1902 May 10	*Harper, A.	Deputy Borough Surveyor, Town Hall, St. Helen's, Lancs.
1903 June 6	Heap, H., A. M. Inst. C.E.	16 Manor Avenue, Grimsby.
G1903 Jan. 17 TA1905 Apr. 29	*Heath, J. R.	Assistant Borough Surveyor, Burslem.
1904 Aug. 26	Henderson, R. T.	City Engineer's Office, City Chambers, Glasgow, N.B.
G1900 Mar. 10 TA1902 May 10	*Hinchsliff, E. R.	Deputy Surveyor, Council Offices, Barry.
1905 Jan. 28	Hipwood, J. W., A. M. Inst. C.E.	Chief Assistant, Borough Engineer's Office, Southend-on-Sea.
G1900 Aug. 25 TA1902 Mar. 22	*Holloway, W. C.	Chief Engineering Assistant, Council Offices, Kettering.
1902 Feb. 22	Horton, J. W., A.M. Inst. C.E.	County Surveyor's Office, Hatfield, Herts.

G1897 July 31 TA1902 Nov. 8	*Jenkins, R. J.	Chief Assistant, Town Hall, Portsmouth.
G1900 June 16 TA1901 Oct. 19	*Jerram, G., A.M. Inst. C.E.	Assistant Surveyor, Town Hall, Walthamstow, N.E.
G1897 June 19 TA1902 Jan. 25	*Johnston, R. W.	Deputy Borough Engineer, Town Hall, Birkenhead.
G1901 June 8 TA1904 Mar. 26	*Jones, H. O.	Assistant Borough Engineer, Folkestone.

Date of Election and Transfer.		
1902 May 10	Ker, A. M., B. Sc. (*Vict.*), A.M. Inst. C.E.	Assistant Borough Engineer, Town Hall, Warrington.
1904 Feb. 27	Kirby, H. C.	Sewerage Engineer, Bloemfontein, South Africa.
1901 Dec. 7	Lashmore, E. W., Assoc. M. Inst. C.E.	District Surveyor, Alma Vale Road, Clifton, Bristol.
G1901 May 11 TA1901 Oct. 19	*Lismer, A. B., A.M.Inst.C.E.	Assistant Engineer, Town Hall, Edmonton.
1904 Sept. 6	McInnes, D.	City Engineer's Office, Glasgow, N.B.
1902 Nov. 8	McKenzie, L. S., A.M.Inst.C.E.	District Surveyor, 63 Queen Square, Bristol.
1903 Mar. 21	Manning, W. R., A. M. Inst. C.E.	Assistant Borough Surveyor, Town Hall, Chelsea.
1904 Aug. 4	Marr, G. E.	District Offices, Hamilton, N.B.
1903 Jan. 17	Marshall, L. P., M. Inst. C.E.	Northern Outfall Works, Beckton, E.
G1900 Apr. 21 TA1901 Dec. 7	*Miller, G. F.	Chief Assistant, Borough Engineer's Office, Hastings.
G1898 Dec. 17 TA1901 Oct. 19	*Mitchell, G.	Tofany Storage Reservoir, Kilco Post Office, Co. Down, Ireland.
1904 Sept. 19	Morrison, A. W.	Burgh Engineer's Office, Edinburgh, N.B.
G1901 Aug. 24 TA1902 Nov. 8	*Neave, J.	Chief Assistant, Engineer's Department, Town Hall, Walthamstow.
1902 Jan. 25	Oakes, H. H...	Assistant Borough Engineer, Town Hall, Bridlington.
1904 Aug. 17	Oliver, J. R...	Burgh Engineer's Department, Edinburgh, N.B.
G1895 June 27 TA1902 July 10	*Openshaw, J., A.M.Inst.C.E.	Engineering Assistant, Town Hall, Salford.
G1902 Mar. 22 TA1904 Oct. 29	*Parr, J. E.	Chief Assistant, Engineer's Office, Handsworth, Birmingham.
1904 Sept. 5	Paterson, J. B.	Deputy Burgh Surveyor, Partick, N.B.
G1900 June 16 TA1902 Feb. 22	*Percival, W.	Assistant Borough Surveyor, Court House, Longton, Staffs.
G1895 Jan. 19 TA1901 Oct. 19	*Perkins, J.	Engineering Assistant, Council House, Birmingham.
1902 Mar. 22	Phillips, G. A., A.M. Inst. C.E.	Deputy County Surveyor, Glamorgan. Town Hall, Bridgend.
G1899 Oct. 21 TA1904 June 25	*Plant, W., A. M. Inst. C.E.	Borough Engineer's Office, Leicester.

Date of Election and Transfer.		
1903 Dec. 12	*Race, A.	Chief Assistant, Borough Engineer's Office, Barrow-in-Furness.
1902 Mar. 22	Ransom, W., A.M. Inst. C.E.	Chief Assistant Surveyor, Worcester. Midhurst, Bath Road, Worcester.
1904 Aug. 31	Reid, M.	Burgh Engineer's Office, Paisley, N.B.
1904 Aug. 5	Robertson, A.	15 Whitehead Street, Paisley, N.B.
1904 Sept. 22	Robertson, R.	Glasgow Main Drainage Works, Partick, N.B.
G1903 June 6 TA1904 Mar. 26	*Roseveare, L., A.M.Inst.C.E.	Council House, Birmingham.
1902 Nov. 8	Rowbottom, J.	Chief Assistant, Borough Surveyor's Office, Ashton-under-Lyne.
1903 June 6	Sadler, F.	Deputy Surveyor, Council Offices, Acton.
1903 June 25	*Saunders, E. Y.	Assistant Borough Engineer, Lowestoft.
G1894 Oct. 20 TA1902 May 10	*Savage, E. B., A.M. Inst. C.E.	Engineering Assistant, Council House, Birmingham.
1902 Nov. 8	*Shackleton, W., A.M. Inst. C.E.	Chief Assistant, Borough Engineer's Office, Hanley.
1905 May 27	Sherren, A. O., A.M. Inst. C.E.	Chief Assistant, Borough Engineer's Office, Dover.
G1899 Dec. 16 TA1901 Oct. 19	*Slater, F. J.	Assistant Surveyor, Town Hall, Camberwell, S.E.
1904 May 28	*Smith, C. P.	Chief Assistant, Town Hall, Greenwich.
1901 Dec. 7	Spurr, F. W.	Chief Assistant, City Engineer's Office, York.
1904 May 28	Spurrell, E. F.	Borough Surveyor, Holborn.
G1895 Jan. 19 TA1901 Oct. 19	*Steele, W. J., A.M. Inst. C.E.	Deputy City Engineer, Bristol.
1904 Aug. 22	Stephen, T. M.	District Offices, Hamilton, N.B.
G1903 June 25 TA1904 Feb. 27	*Stevens, H. L., A.M. Inst. C.E.	Chief Assistant Engineer, Council Offices, Watford.
1904 Apr. 30	Storey, G. E.	Surveyor, Western District, Town Hall, Sheffield.
1903 Mar. 21	Sutcliffe, H.	Deputy Borough Engineer Town Hall, Huddersfield.
1905 Sep. 23	Swarbrick, G.	Deputy Borough Surveyor, Swansea.
G1902 Feb. 22 TA1904 Dec. 3	*Tait, W. I.	Council Offices, Nuneaton.
G1898 Dec. 17 TA1902 Jan. 25	*Taylor, J.	Tramways Engineer, Town Hall, Bradford.
G1900 Dec. 15 TA1903 May 16	*Taylor, P.	Chief Engineering Assistant, Council Offices, Ilford.

Date of Election and Transfer.		
G1899 June 10 TA1905 Sep. 23	*Thackeray, J. R.	Deputy Borough Surveyor, Eastbourne.
1904 June 25	*Thompson, W., A.M.Inst.C.E.	Deputy Borough Engineer, Burton-on-Trent.
1905 Jan. 28	Waldram, R. E.	Assistant Borough Engineer, Town Hall, Woolwich.
G1904 May 28 TA1904 Dec. 3	*Walton, J. S.	Borough Engineer's Office, Torquay.
1905 Sep. 23	Ward, A. W., A.M. Inst. C.E.	Assistant Borough Engineer, Northampton.
1903 July 25	*Watmore, Jas.	Assistant Surveyor, Council Offices, Aldershot.
G1899 June 10 TA1902 Mar. 22	*Weir, J. S., A.M. Inst. C.E.	Chief Assistant, Borough Surveyor's Office, Halifax.
G1902 July 10 TA1905 Jan. 28	*Whitaker, G. H., A.M. Inst. C.E.	Chief Assistant, Borough Engineer's Office, Sunderland.
1903 May 16	White, W. H. J., A. M. Inst. C.E.	Deputy Borough Engineer, Town Hall, Cheltenham.
G1902 Nov. 8 TA1904 Feb. 27	*Wibberley, J.	Engineering Assistant, Municipal Offices, Plymouth.
1902 Mar. 22	Williams, H. B.	Chief Assistant, Borough Engineer's Office, Workington.
1902 July 10	Williams, J.	Assistant Borough Surveyor, Town Hall, Hampstead, N.W.
G1898 June 30 TA1901 Dec. 7	*Willis, E., Assoc. M. Inst. C.E.	Chief Engineering Assistant, Council Offices, Willesden, N.W.
1903 June 6	Wilson, A., B. Sc. (*Lond.*), Assoc. M. Inst. C.E.	Sanitary Commissioner's Office, Gibraltar.
G1898 June 30 TA1901 Dec. 7	*Wilson, F., A.M. Inst. C.E.	District Surveyor, 63 Queen Square, Bristol.
G1891 Aug. 1 TA1901 Oct. 19	*Yarwood, H.	Assistant Borough Surveyor, Town Hall, Rochdale.
G1901 June 8 TA1902 Feb. 22	*Yelland, T.	Assistant Borough Engineer, Bury.

GRADUATES.

All Graduates hold the Certificate of the Association.

Date of Election.		
1893 Oct. 2	BALL, J. B., M. Inst. C.E.	Engineer's Office, L.D. & E.C. Railway, Chesterfield.
1901 Aug. 24	BARKER, H. W.	Surveyor to the Urban District Council, Walmer.
1905 June 22	BARKER, H. W.	Council House, Handsworth, Birmingham.
1890 Mar. 29	BAYLEY, G. H., A.M.Inst.C.E.	19 Cooper Street, Manchester.
1897 July 31	BEARD, E. T., M. Inst. C.E.	4 The Crescent, Scarborough.
1902 Mar. 22	BERRINGTON, E. E. W.	28 Victoria Street, Westminster, S.W.
1903 Dec. 12	BIKER, W. J. E.	Municipal Offices, Harrogate.
1900 June 16	BLAKEWAY-PHILLIPS, R.	City Engineer's Office, Westminster, S.W.
1901 Aug. 24	BLANCHARD, R.	Town Hall, Leicester.
1889 June 8	BLIZARD, J. H., A.M.Inst.C.E.	Lansdowne House, Southampton.
1905 Jan. 28	BRADLEY, C. G.	Borough Engineer's Office, Barrow-in-Furness.
1892 Oct. 15	BRADSHAW, J. B., A.M. Inst. C.E.	R.E. Office, 14 Elliott Street, Liverpool.
1896 June 25	BRUCE, W.	Burgh Engineer's Office, Edinburgh.
1889 July 4	BRYANS, J. G., Assoc. M. Inst. C.E.	Sectional Engineer, Palermo Station, F.C.P., Buenos Ayres.
1905 May 27	BULL, E. M.	Council Offices, Finchley, N.
1899 June 29	BURGESS, R. W.	Town Hall, Stratford, E.
1903 June 6	BUTLER, H. L.	Surrey House, Surrey Lane, Battersea.
1905 June 22	BUTLER, R.	"Woodthorpe," Prospect Road, Tunbridge Wells.
1904 June 25	BUTT, E. E. W.	Council Offices, Birmingham.
1902 July 10	BUTTON, F. E.	City Surveyor's Office, Manchester.
1902 Feb. 22	CAMM, E.	Town Hall, Port Elizabeth, S. Africa.
1903 Dec. 12	CARTER, S. F. R.	Town Hall, Hounslow.
1897 June 19	CARTLEDGE, J. R.	Assistant Surveyor, District Council Offices, Barnes, S.W.
1904 May 28	CATTLIN, O.	Borough Surveyor's Office, 197 High Holborn, W.C.
1904 Dec. 3	CLARKE, R. E.	Public Offices, Arnold, Notts.
1894 July 7	CLEGG, H., A.M. Inst. C.E.	Surveyor to the Urban District Council, Felixstowe.
1903 Dec. 12	COCHRANE, J.	15 Ure Place, Montrose Street, Glasgow.
1904 May 28	COWLISHAW, H. H.	3 Beacon Close Terrace, Canterbury Street, New Brompton, Kent.
1904 Jan. 23	COX, C. E.	Windmill Hill, Cradley. Cradley Heath.
1897 June 19	CRESWELL, W. T.	11 Victoria Street, S.W.
1904 Dec. 3	CROOK, F.	45 Knowsley Road, Bolton.

Date of Election.		
1892 July 11	Cross, F. W., A.M. Inst. C.E.	45 Bradford Street, Walsall.
1905 June 22	Cross, W. G.	25 Arundel Road, Tunbridge Wells.
1903 June 6	Cubitt, H. W.	County Hall, Spring Gardens, S.W.
1905 Jan. 28	Darby, A. E.	194 Rishton Lane, Bolton.
1901 June 8	Davidge, W. R.	London County Council Offices, 19 Charing Cross Road, W.C.
1902 July 10	Dawkins, F.	Borough Surveyor's Office, Bournemouth.
1902 July 10	Deeley, G. P.	Moushall, Amblecote, Brierley Hill, Staffs.
1898 June 30	Dent, J. P.	1 Woodside Terrace, Nelson, Lancashire.
1904 May 28	Draper, J.	Council House, Handsworth, Birmingham.
1903 Oct. 17	Duncan, L. G.	10 Hanover Buildings, Southampton.
1898 Dec. 17	Essex, E. H., A.M. Inst. C.E.	Town Hall, Leyton, N.E.
1905 May 27	Farrar, W.	Town Hall, Todmorden.
1886 Sept. 11	Fenton, W. C.	14 St. James' Row, Sheffield.
1891 June 25	Finch, A. R., A.M. Inst. C.E.	Town Hall, Kensington, W.
1900 June 16	Fisher, R.	87 Inman Road, Harlesden, N.W.
1903 July 25	Ford, J.	Lower House, Branscombe, Axminster.
1903 Feb. 21	Foster, J. W.	Town Hall, Bradford.
1903 June 6	Foster, W. A.	Park View, Manchester Road, Accrington.
1903 June 25	Gettings, S. S.	Town Hall, West Bromwich.
1899 June 10	Gibson, W. S.	"Everitta," Finchley Lane, N.W.
1888 July 12	Glass, S. N., A.M. Inst. C.E.	16 Ravenscroft Road, Chiswick.
1905 Jan. 28	Goddard, F. B.	87 Cicada Road, Wandsworth.
1905 June 22	Greenhill, F. G.	"Moorhaven," Headstone Road, Harrow.
1898 Jan. 15	Grimley, F. C.	Depôt Barracks, Harwich.
1904 Dec. 3	Grove, A.	Christine Villa, Clark Street, Stourbridge.
1905 June 22	Gunson, E., A.M. Inst. C.E.	c/o Grindlay & Co., Calcutta.
1905 June 22	Hadfield, J. R.	Borough Surveyor's Office, Bedford.
1904 Jan. 23	Harkness, J.	20 Duke Street, Edinburgh.
1901 June 27	Harlow, W. W. R.	City Engineer's Office, Carlisle.
1901 June 8	Harris, K. J. S.	Vestry Hall, Piccadilly.
1903 June 25	Harrison, P. T.	Town Hall, Fulham.
1905 Oct. 28	Hassall, J.	Borough Engineer's Office, Worthing.
1904 May 28	Hatton, J	1 Mill Cliff, Buxton, Derbyshire.
1893 Jan. 14	Hellawell, O.	Town Hall, Withington, Manchester.
1903 Oct. 17	Hill, H. F.	Town Hall, Ilford.
1896 June 25	Hills, O. C.	360 Mare Street, Hackney, N.E.
1900 June 16	Hobson, E.	117 Oakland Road, Hillsborough, Sheffield.
1888 July 12	Houghton, J.	King's Heath, Birmingham.

Date of Election.		
1904 Oct. 29	Howell, H. H.	63 Queen Square, Bristol.
1903 Jan. 17	Howells, D. P.	16 Ropewalk, Neath, S. Wales.
1899 June 10	Hutchings, W. A.	Town Hall, Islington, N.
1904 Dec. 3	Hutchinson, H. F.	2 Queen's Road, Chorley.
1903 Dec. 12	Jacques, H. S.	Municipal Offices, Cheltenham.
1905 Jan. 28	Jennings, W.	Borough Engineer's Office, Leyton.
1903 July 25	Jones, T.	53 Princes Street, Southport.
1895 Oct. 19	Julian, J.	Borough Surveyor's Office, Cambridge.
1896 June 25	Kiesser, W. H. G., A.M.Inst. C.E.	City Engineer's Office, Bristol.
1903 June 25	Knight, R. R.	Council Offices, Bromley, Kent.
1903 June 25	Knowles, G. P., A.M. Inst. C.E.	Engineer's Department, L.C.C., Spring Gardens, S.W.
1903 June 25	Lees, H. B.	P.W.D. Colombo, Ceylon.
1904 June 25	Lewis, H. M.	Town Hall, Staines.
1904 Dec. 3	Line, H. W.	L.C.C., 19 Charing Cross Road, S.W.
1905 Sep. 23	Lyddon, A. J.	Borough Engineer's Office, Town Hall, Reading.
1905 May 27	McArd, A. J.	Edge Hill, Whitehaven.
1900 Dec. 15	MacDonald, K. G.	13 Charles Street, St. James's, S.W.
1905 May 27	Maitland, W. H.	51 Cable Road, Hoylake, Cheshire.
1903 June 25	Mann, E. E.	Borough Engineer's Office, Southampton.
1904 May 28	Mansfield, F.	1 Castle Green Villas, Mill Street, Hereford.
1903 Jan. 17	Marrian, H. G., Assoc. M. Inst. C.E.	City Surveyor's Office, Manchester.
1894 Jan. 13	Martin, E. B., A.M.Inst.C.E.	City Engineer's Office, Leeds.
1903 Jan. 17	Masters, W. H.	Glencairn, Arthur Road, Southampton.
1905 Jan. 28	Mathew, H. B.	Borough Engineer's Office, Dover.
1905 May 27	Matthew, S.	South Villa, Crow Nest Park, Dewsbury.
1900 June 16	Mattinson, H., A.M.Inst.C.E.	55 Piccadilly, Manchester.
1904 May 28	Millar, P.	Borough Engineer's Office, Southampton.
1901 Oct. 19	Milnes, B.	Town Hall, Birkenhead.
1905 May 27	Minors, E.	City Engineer's Office, Worcester.
1905 June 22	Morgan, G. L.	"Ardwyn," The Parade, Pontypridd.
1899 June 10	Moss, P. A.	121 Highbury Hill, Highbury, N.
1902 Jan. 25	Moss, W.	30 Hale Lane, Failsworth, Manchester.
1902 July 10	Nathanielsz, A. H., Assoc. M. Inst. C.E.	P.W.D., Bungalow, Wegambo, Ceylon.

Date of Election.		
1904 Dec. 3	Needham, J. E.	Municipal Engineer's Office, Shanghai.
1904 May 28	Nicholls, R.	Borough Engineer's Office, Southampton.
1896 June 25	Nightingale, C. F.	"Endellion," Buchanan Road, Walsall.
1905 Sep. 23	Nighy, J.	"Highcliffe," Fulwich Road, Dartford.
1905 Jan. 28	Owen, J.	Borough Engineer's Office, Colchester.
1901 Aug. 24	Oxberry, F. W.	32 East Mount Road, York.
1899 Oct. 21	Palmer, G. F.	111 Victoria Road, Charlton, S.E.
1901 Feb. 6	Palmer, W. L. F.	City Engineer's Office, Bristol.
1904 May 28	Parker, J.	9 Winchester Road, Ilford, Essex.
1904 June 25	Pearson, T. G.	Town Hall, Barrow-in-Furness.
1896 Feb. 22	Perkins, T. L., A.M. Inst.C.E.	P. W. D., Hong Kong.
1903 Feb. 21	Perrott, E. S.	6 Elliston Road, Redland, Bristol.
1903 Dec. 12	Persey, W. C.	Town Hall, Barrow-in-Furness.
1901 Aug. 24	Pickin, W. H.	L.C.C. Works Department, Belvedere Road, Lambeth, S.E.
1904 May 28	Piercy, M. A.	41a Burnbury Road, Balham, S.W.
1888 Sept. 15	Pritchard, T., M. Inst. C.E.	264 Gresham House, Old Broad Street, E.C.
1898 June 30	Quick, A. H., Assoc. M. Inst. C.E.	15 Fernholme Road, Newlands, S.E.
1904 Dec. 3	Quirk, J. J.	2 St. Ives Mount, Armley, Leeds.
1900 Dec. 15	Rawstron, C. O.	Surveyor's Office, Rural District Council, Lichfield, Staffs.
1901 June 8	Read, F., Assoc. M. Inst. C.E.	Public Offices, Pentre, Rhondda, Glam.
1902 Nov. 8	Redford, W. T.	Town Hall, Eccles, Lancs.
1899 Mar. 25	Richards, E. P.	Engineer's Office, Derwent Valley Water Board, Bamford, via Sheffield.
1904 May 28	Richmond, W. S.	Municipal Offices, Highgate, N.
1901 Aug. 24	Riley, J.	Drainage Engineer's Office, Cape Town, S.A.
1900 Feb. 10	Ross, D.	Brynmenyn near Aberkenfig, Glam., South Wales.
1900 June 16	Rousell, A. J., A.M.Inst.C.E.	Borough Engineer's Office, Worthing, Sussex.
1905 June 22	Sagar, J. H.	Council Offices, High Street, Poplar.
1904 May 28	Schlund, W. T. S.	54 Macoma Villas, Plumstead Common.
1902 July 10	Shepherd, G. G.	Town Hall, Ilford.
1899 June 29	Simms, F.	Town Hall, Sheffield.

Date of Election.		
1905 May 27	Sissons, F. P.	City Engineer's Office, Norwich.
1905 Oct. 28	Slater, E. A., A.M. Inst. C.E.	201 Malden Road, Colchester.
1898 Jan. 15	Smith, G. H.	1 Worcester Road, Wimbledon, S.W.
1905 Mar. 4	Snape, A. E.	46 Wood Street, Woolwich.
1898 June 30	Spink, J.	City Surveyor's Office, Manchester.
1899 June 29	Stanton, F. W. S., A.M. Inst. C.E.	c/o Messrs. J. Mansergh & Sons, 5 Victoria Street, S.W.
1904 June 25	Stephenson, W. E., A.M.Inst. C.E.	City Engineer's Office, Leeds.
1904 May 28	Sutherland, D. S.	Hebe Cottage, Thynne Street, West Bromwich.
1898 June 30	Sutton, W. F.	Water Department, Broad Street, Birmingham.
1900 Dec. 15	Taylor, H. T.	3 North Terrace, Gt. Meols, Hoylake, Cheshire.
1902 July 10	Taylor, S.	Town Hall, Manchester.
1904 June 25	Thorp, W. O.	Surveyor to the Urban District Council, Malvern.
1902 July 10	Tomlinson, J. W., A.M. Inst. C.E.	St. Mary's Hall, Coventry.
1905 Sep. 23	Tonge, J. A.	125 Nottingham Road, Mansfield.
1900 June 16	Towner, H. V.	P.W.D., Malacca, Straits Settlements.
1900 June 16	Tremelling, H., Assoc. M. Inst. C.E.	Borough Engineer's Office, Newport, Mon.
1903 Jan. 17	Treseder, F. H.	The Nurseries, Cardiff.
1904 May 28	Tulley, G. W.	95 Slateford Road, Edinburgh.
1904 May 28	Varey, J. A.	Westhill House, Chapel Allerton, Leeds.
1905 May 27	Vernon, A.	Town Hall, Upper Street, Islington.
1902 Nov. 8	Walker, A. H.	128 Prince of Wales Road, London, N.W.
1888 Jan. 14	Ward, F. D., A. M. Inst. C.E.	38 High Street, Welshpool.
1897 June 19	Webb, F.	Town Hall, Chelsea.
1898 Jan. 15	Wells, F. B., Assoc. M. Inst. C.E.	c/o The Great Southern Railway Co., Buenos Aires, South America.
1902 Sept. 6	West, A. S.	Borough Engineer's Office, Harrogate.
1902 Jan. 25	White, C. D.	Council Offices, Hanwell.
1901 June 8	Whiteford, E. H., A.M. Inst. C.E.	Engineer's Office, Derwent Valley Water Board, Bamford, near Sheffield.
1901 June 27	Willett, A. J.	18 Castledine Road, Anerley, S.E.
1902 July 10	Wilkinson, F., A.M.Inst.C.E.	Town Hall, Rochdale.
1901 Aug. 24	Wilkinson, H. F., A.M. Inst. C.E.	Fulford House, The Crescent South Tottenham, N.

Date of Election.		
1895 June 27	**Williams, D. S.**	c/o G. R. Strachan, 7 Victoria Street, S.W.
1901 Dec. 7	**Williams, J. H.**	Deputy Borough Engineer, Town Hall, Todmorden.
1900 Dec. 15	**Wills, A. J.**	2881 Woodbrook Avenue, Druid Hill Park, Baltimore, Ma., U.S.A.
1901 Aug. 19	**Wilson, H. B.**	Town Hall, Wood Green, N.
1900 July 19	**Wrack, W. P.**	117 High Street, Poplar, E.
1904 June 25	**Wright, F. W.**	19 Church Street, Stratford-on Avon.

STANDING COMMITTEES.

PARLIAMENTARY AND GENERAL PURPOSES COMMITTEE.

THE PRESIDENT (*ex-officio*).
J. P. BARBER (Islington), *Chairman.*

W. N. Blair (St. Pancras).
J. W. Cockrill (Great Yarmouth).
C. H. Cooper (Wimbledon).
A. D. Greatorex (West Bromwich).
W. Harpur (Cardiff).
Chas. Jones (Ealing).
A. B. McDonald (Glasgow).
J. Price (Birmingham).
O. C. Robson (Willesden).
H. T. Wakelam (Westminster).
W. Weaver (Kensington).
T. H. Yabbicom (Bristol).

FINANCE COMMITTEE.

THE PRESIDENT (*ex-officio*).
W. WEAVER (Kensington), *Chairman.*

J. P. Barber (Islington).
J. W. Bradley (Westminster).
J. A. Brodie (Liverpool).
A. Creer (York).
W. Harpur (Cardiff).
Chas. Jones (Ealing).
J. S. Pickering (Nuneaton).
J. Price (Birmingham).
R. Read (Gloucester).
C. F. Wike (Sheffield).
T. H. Yabbicom (Bristol).

PAPER COMMITTEE.

THE PRESIDENT (*ex-officio*).
H. T. WAKELAM (Westminster), *Chairman.*

J. P. Barber (Islington).
W. N. Blair (St. Pancras).
C. H. Cooper (Wimbledon).
A. Creer (York).
A. D. Greatorex (West Bromwich).
A. B. McDonald (Glasgow).
J. Price (Birmingham).
R. J. Thomas (Aylesbury).
R. Read (Gloucester).
J. S. Pickering (Cheltenham).

THE
INCORPORATED ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS.

THIRTY-SECOND ANNUAL MEETING.

NORWICH, *June* 22, 23 *and* 24, 1905.

THE Members assembled in the Technical Institute, where the Mayor (H. Z. T. Flowers, Esq.), the Sheriff (H. L. Clark, Esq.) and Members of the City Council offered the Association a very hearty welcome to Norwich.

The President, Mr. A. T. Davis, on behalf of the Association, returned thanks for the kind welcome offered them.

The Secretary then read the Minutes of the last Annual General Meeting, which were confirmed and signed.

The Secretary read the Council's Annual Report:—

ANNUAL REPORT.

The Council have pleasure in presenting their Annual Report.

DISTRICT MEETINGS.

Since the last Annual General Meeting eight District Meetings have been held. At Glasgow (Scottish district) on July 27, 1904; at the Birmingham, Tame and Rea District Drainage Works (Midland district) on September 3, 1904; at Withington (Lancashire and Cheshire district) on September 24, 1904; at Westminster (Metropolitan district) on February 10, 1905; at Cleckheaton (Yorkshire district) on March 18, 1905; at Birmingham (Midland district) on April 1, 1905; at Market Harborough (Midland district) on May 13, 1905; and at Gloucester (Western district) on June 3, 1905.

NEW DISTRICT.

A new district of "Africa," has been formed, with Mr. J. Cook, City Engineer of Cape Town, as the hon. district secretary. It is hoped thus to facilitate the work of the Association in this growing and important field of action.

ROLL OF THE ASSOCIATION.

During the financial year ending April 30 last, 117 new Members, consisting of 53 Ordinary Members, 25 Associates, and 39 Graduates, have joined the Association. Nine Members have resigned; nineteen names have been written off or have not been re-elected; and the Council record with regret the deaths of E. R. S. Escott (past-President), W. G. Laws (past-President), W. Beatson, A. J. L. Evans, W. Goldsworth, S. Reid, and J. W. M. Smith (hon. district secretary, North Wales).

The number on the Roll of the Association at the close of the year was 10 Honorary Members, 852 Ordinary Members, 123 Associates, and 158 Graduates—making a total of 1143.

TABLE SHOWING NUMERICAL INCREASE.

—	1899 to 1900.	1900 to 1901.	1901 to 1902.	1902 to 1903.	1903 to 1904.	1904 to 1905.
Hon. Members	9	10	9	8	10	10
Members	798	808	823	810	813	852
Associates	..	..	58	83	93	123
Graduates	123	148	129	133	144	158
Total	930	966	1019	1034	1060	1143

The Council have transferred 3 Associates to the class of Members, 12 Graduates to the class of Members, and 6 Graduates to the class of Associates, these gentlemen occupying positions qualifying them under the Articles for the several transfers.

In the totals above given 30 Scotch Members and 16 Scotch Associates are included, these having joined under By-law 23, passed at the last Annual Meeting.

FINANCES.

The audited Balance-Sheet and Statement of Accounts, which accompany this Report, show a balance in hand, on April 30 last, of 83*l.* 15*s.* 6*d.* The auditors expressed pleasure at the amount of arrears that have been got in during the year. The expenditure account is very heavy, as it includes a larger volume than usual, together with the quinquennial index.

The statement of assets and liabilities again allows the financial state of the Association to be reported as very satisfactory.

EXAMINATIONS.

Since the last Report four examinations have been carried out. Two were held at Manchester, in October 1904, when 39 candidates presented themselves for examination, of whom 20 satisfied the examiners and were granted their certificates, and two examinations in London, in April 1905, when 49 candidates presented themselves for examination, of whom 23 satisfied the examiners and were granted their certificates. In addition to the examination to be held at Liverpool in October, it is intended, should sufficient candidates present themselves, to hold an examination at Glasgow, also in October, when the fourth section of the examination will be taken in Scotch Law. On the advice of the Board of Examiners, the Council have divided Engineering into two papers, giving this most important subject an additional two hours. The Council, after very careful consideration, have made certain alterations in the schedule of educational attainments required, which facilitate proof of the candidates having been thoroughly educated. No candidate is, under any circumstances, allowed to sit for the examination who cannot give evidence of having received a sound education, and at least produce certificates in English and in Mathematics.

PREMIUMS.

The Council have awarded the premium of 10*l.* to Mr. Creer for his paper entitled "Sewerage and Sewage Disposal of York," read at the District Meeting held at York, May 14, 1904; and the premium of 5*l.* to Mr. P. H. Palmer for his paper, "The Water Supply of Hastings," read at the District Meeting held at Hastings on September 10 and 11, 1903.

PAPERS TO AUTHORS.

The Council have decided in future to present copies of Papers read at Meetings to their Authors.

NEW COUNCIL.

The Scrutineers, having examined the ballot lists, report the following gentlemen as elected for the new Council:—

President.—Mr. A. E. Collins.

Vice-Presidents.—Messrs. J. Patten Barber, J. Price, and C. F. Wike.

Ordinary Members of Council.—Messrs. W. N. Blair, J. W. Bradley, J. A. Brodie, C. H. Cooper, A. Creer, H. A. Cutler, A. D. Greatorex, E. P. Hooley, A. B. McDonald, J. Paton, J. S. Pickering, S. S. Platt, R. Read, H. T. Wakelam, and A. E. White.

Hon. Secretary.—Charles Jones.

Hon. Treasurer.—Lewis Angell.

The Council note with gratification that the Members have given to Ireland another Council representative in the person of Mr. Cutler, and that Scotland continues to be represented by Mr. McDonald. All members of Council seeking re-election have been re-elected, thus securing that continuity of work and policy which is so vital to the best interests of the Association. The Council having re-elected Mr. O. C. Robson, the list of elective Past-Presidents remains the same as that for the last year.

BUILDING BY-LAWS.

During the past year the special Committee appointed to consider the subject of building by-laws have held 21 meetings, and have submitted an exhaustive report to the Council, recommending various amendments to the model code for urban and rural districts issued by the Local Government Board. In considering this question the Committee have particularly had in view the desirability of removing certain restrictions in the by-laws in order to allow of the cheaper construction of buildings, particularly with regard to dwellings for the working classes, both in urban and rural districts; and in suggesting such amendments and modifications they have carefully kept in mind the necessary stability, security against fire, and sanitary arrangements of the buildings. The report having been considered and approved by the Council, has been submitted to the Local Government Board, who are giving the subject their consideration, and it is confidently hoped that the labours of the Committee may not have been in vain.

CERTIFICATES TO PRESIDENTS, MEMBERS, ETC.

The Council have designed certificates to be issued to all Presidents, Honorary Members, Members, Associates, and Graduates of the Association. General satisfaction appears to have been given by this action.

SALE OF "PROCEEDINGS" AT REDUCED COST.

The Council have deemed it desirable to offer to Members of the Association the first twenty volumes of the "Proceedings" at the reduced price of 5*s*. per volume.

PAYMENT OF EXPENSES.

During the year the Council have further pursued their efforts to obtain such amendment of the Conferences Act as will put the engineer and surveyor in the same position, in the matter of payment of expenses incurred in attending meetings, as are the clerk and the medical officer. The Urban and Rural District Councils' Associations have been asked to co-operate with your Council, and favourable replies have been received from them. Much is hoped from the accession of strength which the co-operation of these two influential bodies will bring.

LEGAL PROTECTION TO MEMBERS.

The Council have for some time past had under their consideration a dispute between a Member and the Corporation by whom he was employed, as to the ownership of plans and payment therefor. The opinion of an eminent Counsel has been obtained, and the Council has the matter still under consideration.

A DEFENCE FUND.

The Council have had their attention directed to the question of the formation of a defence fund for the protection of Members. After careful consideration, it was not found possible at present to adopt such a scheme.

LEGAL ADVISER.

A further proposition—that a legal adviser should be retained for the assistance of Members—also received careful attention. Keeping in mind the fact that the Association has its official solicitors, and that cases may always be laid before the Council for consideration, the Council thought it undesirable to appoint such legal adviser.

PUBLIC HEALTH BILL (QUALIFICATION AND SECURITY OF TENURE).

The Council gave careful consideration to the Public Health Bill (1905), promoted by the British Medical Association, the Society of Medical Officers of Health, and the Sanitary Inspectors' Association; and addressed a communication to these Societies, with a view of obtaining the inclusion of Municipal and County Engineers and Surveyors, expressing approval of legislation on the lines proposed and offering hearty co-operation. Unfortunately, this Bill, which would ensure that security of tenure which is an absolute necessity to the efficient administration of the public engineering departments, will not be proceeded with this session. The efforts of your Council will not be relaxed until success is attained.

LONDON BUILDING ACTS AMENDMENT BILL, 1905.

This Bill has also engaged the attention of your Council, and a resolution opposing the Bill was addressed to every London authority and the Members of Parliament representing London divisions. It is satisfactory to note that the general opposition to the Bill has resulted in the withdrawal of all the clauses except those relating to protection against fire.

ROYAL INSTITUTE OF BRITISH ARCHITECTS' MEMORIAL.

The Council carefully considered a memorial issued by the Royal Institute of British Architects and kindred Societies to public authorities in reference to architectural work executed by Engineers or Surveyors to municipal authorities. It was not considered of sufficient importance to warrant any action being taken.

REPORTS, IN PAMPHLET FORM, OF LAW CASES, ARBITRATIONS, ETC.

The Council have decided to issue reports, in pamphlet form, of law cases and arbitrations bearing directly upon municipal and county engineering, to Members of the Association. They trust that Members will find these reports valuable, and will co-operate in this work by sending to the Secretary reports of any cases that may become known to them.

PUBLICATION OF "DIGEST OF COUNCIL MEETINGS."

It having been considered desirable to keep the Members informed as to the work of the Council throughout the year, a digest of the work of each meeting is now published in those technical papers particularly applying themselves to the work of Municipal and County Engineers.

CONCLUSION.

It will be seen that the Council have during the past year dealt with a mass of work greater than in any previous year. Without the loyal services of the various standing Committees—particularly the By-laws Committee—such enhanced work could not have been accomplished. And to the gentlemen forming these Committees the thanks of the Association are specially due.

CHARLES JONES, *Hon. Sec.*
THOMAS COLE, *Secretary.*

On the motion of the President, seconded by Mr. A. E. Collins, the Report was received and adopted.

A suggestion by Mr. W. H. Prescott that the Annual Reports should in future be printed and circulated was referred to the Council for consideration.

The Association's 10*l.* Premium of books was then presented to Mr. A. Creer for his paper on "The Sewerage and Sewage Disposal of York," and the 5*l.* Premium to Mr. P. H. Palmer, for his Paper on "The Water Supply of Hastings."

It was moved, seconded, and carried, that the Hon. District Secretaries be re-elected pending Meetings in their several Districts.

Mr. R. A. MacBrair and Mr. S. Stallard were re-elected Auditors for the ensuing year.

Messrs. F. Harris, T. W. A. Hayward, H. Shaw, and O. E. Winter, were elected Scrutineers for the ensuing year.

Mr. Davis then introduced his successor, Mr. Arthur E. Collins, and vacated the chair in his favour.

Mr. C. Jones proposed a hearty vote of thanks to the retiring President for his services to the Association during the past year. This was seconded by Mr. Weaver, and carried with acclamation.

Mr. Davis acknowledged the vote.

Mr. Collins then read his Inaugural Address,* a hearty vote of thanks for which was proposed by Mr. J. Patten Barber, seconded by Mr. A. D. Greatorex, and carried unanimously.

The following papers were read and discussed:—

"Suggested Amendments to the Model Building By-laws for New Streets and Buildings," by A. D. Greatorex. "Administration by Municipal Engineers," by E. J. Elford. "Armoured or Reinforced Concrete," by P. H. Palmer. "Reinforced Concrete Piling," by A. R. Galbraith. "Adaptation of Highways for Modern Traffic," by C. H. Cooper. "Tramway Materials," by J. Owen; and "Water Supply of Cromer," by T. Pritchard.

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* This Address and the Papers read at the Meeting will be found at the end of the Volume.

A cordial vote of thanks was accorded to the Mayor and Corporation for the use of St. Andrew's Hall and the Technical Institute for the purposes of the Meeting.

Dr. STATEMENT OF RECEIPTS AND EXPENDITURE

RECEIPTS.	£	s.	d.
To Balance, May 1, 1904	58	7	11
„ Balance of Petty Cash in hands of Secretary, May 1, 1904	6	6	5
„ Entrance Fees of Members and Associates	29	8	0
„ Subscriptions	925	6	0
„ New Graduates	17	17	0
„ Subscriptions in advance	66	15	0
„ Arrears	116	6	6
„ Sale of 'Proceedings'	34	17	7
„ Examination Fees	308	14	0
„ Interest on Investments	45	4	5
„ Subscription received by Bank (sender untraced)	1	1	0
„ Balance of Funds of Scotch Association	8	6	0
£	1618	9	10

Dr. STATEMENT OF ASSETS

LIABILITIES.	£	s.	d.
To Estimated Liability on Vol XXXI.	40	0	0
„ Sundry Printing	10	0	0
„ Sundry Creditors	120	0	0
„ Balance	1440	0	4
£	1610	0	4

Examined with the vouchers and

FOR THE YEAR ENDING APRIL 30, 1905. Cr.

EXPENDITURE.	£	s.	d.	£	s.	d.
By Reports of Meetings		..		54	12	0
„ Examiners' Fees and Expenses		..		144	3	5
„ Messrs. Clowes, for Vol. XXX. and sundry printing		..		563	17	0
„ Compiling Index		..		30	0	0
„ Scrutineers' Expenses		..		8	5	6
„ Auditors' Expenses		..		1	11	6
„ Meetings, Expenses		..		28	15	4
„ Printing and Stationery		..		13	9	4
„ Illustrations for Volume		..		66	5	6
„ Rent of Telephone		..		9	10	0
„ Secretary, Salary		..		275	0	0
„ Allowance to Secretary for Assistant		..		82	0	0
„ Rent of Office and Coals		..		78	19	8
„ Bankers' Charges		..		0	18	3
„ Solicitors' Charges		..		4	4	0
„ Office Expenses		..		2	4	6
„ Return of Subscription		..		1	1	0
„ Furniture		..		51	8	1
„ Petty Cash—						
Postages	35	5	6			
General	18	11	8			
Balance in hands of Secretary	2	9	3			
				56	6	5
„ Travelling Expenses		..		21	1	6
„ Examination Expenses		..		36	6	10
„ Hire of Rooms		..		4	14	6
„ Balance carried forward		..		83	15	6
			£	1618	9	10

AND LIABILITIES. Cr.

ASSETS.	£	s.	d.	£	s.	d.
By Balance at Bank, May 1, 1905		..		83	15	6
„ Balance of Petty Cash		..		2	9	3
„ £490 Southampton Corporation Stock at 89		..		436	2	0
„ £553 12*s.* 9*d.* India 2½ % Stock at 82		..		453	19	7
„ £261 14*s.* 7*d.* London County Council 2½ % Consols at 81		..		212	0	0
„ £200 Metropolitan 2½ % Consolidated Stock at 84		..		168	0	0
„ Loan to San. Insp. Joint Exam. Board		..		15	0	0
„ Subscriptions in Arrear	128	8	6			
Less 50 % bad	64	4	3			
				64	4	3
„ 'Proceedings' in Stock	345	19	0			
Less 75 %	259	9	3			
				85	9	9
„ Office Furniture		..		89	0	0
			£	1610	0	4

found correct, *May* 10, 1905.

SIDNEY STALLARD } *Auditors.*
R. A. MACBRAIR

LEWIS-ANGELL, *Hon. Treasurer.*
CHARLES JONES, *Hon. Secretary.*
THOMAS COLE, *Secretary.*

SCOTTISH DISTRICT MEETING AT GLASGOW.

July 27, 1904.

Held in the Burgh Court Hall, City Chambers.

WILLIAM WEAVER, M. INST. C.E., PAST-PRESIDENT,
in the Chair.

THE CHAIRMAN: Mr. A. T. Davis, who was elected and installed as President at the Annual Meeting at Shrewsbury, a fortnight ago, has kindly allowed me to take the Chair this morning in order that I might welcome the Scottish Members coming into the fold of the Association, and he has left that duty and pleasure to me, inasmuch as I virtually initiated the movement that we are now completing. On behalf of the Association and its Members, I beg to tender to our Scottish brethren who have amalgamated with us, a hearty welcome to our ranks, and I trust that the amalgamation which we effect this morning may be of mutual advantage. I am quite sure that it is to the interest of all the Members holding appointments throughout Great Britain to be in touch one with another, for the object of both mutual improvement and support, and I trust that future events will prove the wisdom of our action. I therefore beg to give you a hearty welcome, and to express my own personal feelings of pleasure in meeting you here this morning.

Mr. A. B. McDONALD: On behalf of the Scottish Association, which has now ceased to exist, I beg to acknowledge the very kind observations that you have been pleased to address to us, and I cordially acquiesce and thoroughly believe in the accuracy of your anticipation that the amalgamation will be of mutual benefit. I am quite sure that the strong current of Scottish blood, which is to be infused into the English Association, cannot be otherwise than advantageous, and I am quite sure we, too, shall benefit from the kindly relations with our English confrères. I hope and believe that the two Associations now amalgamated will prove of the highest benefit to the profession, and I trust that we shall all avail ourselves of the opportunities that now offer of attending the meetings, both in London and the provincial districts of the Association.

ELECTION OF HONORARY DISTRICT SECRETARY.

It was proposed by Mr. Pritty, seconded by Mr. Massie, that Mr. Bryce be elected Honorary Secretary for the Scottish District. This was cordially supported by the Chairman and carried unanimously.

MR. BRYCE: I have to thank you very much for the honour you have conferred upon me, but I must say it is only on condition that I get relieved next year.

BUILDING BY-LAWS.

MR. BRYCE: I have asked your permission, sir, to make a statement about building by-laws. This matter is so urgent that I think this is a very fitting time to bring it up. Scottish surveyors know very well that, in the new By-laws Act of 1903, we have got authority to frame very comprehensive building by-laws for new buildings and drainage. I think the list is more comprehensive than that comprised in the model by-laws of England; however, I may be wrong on that point. Now, I think, is the time to appoint a committee of our Scottish Members to frame a uniform code of by-laws in respect to Scotland. There are a great many local differences which would alter by-laws for one particular town here and there, but on the main points the by-laws could be made uniform, and be adapted to Scottish practice. We know the English surveyors are also looking into the matter of their by-laws, and making suggested improvements on the model by-laws of England, and probably we might get some hints from them in this matter. But this is entirely a Scottish affair. There is also the question of the form of the by-law as well as of uniformity. There has been a good deal of discussion lately about by-laws being too fixed and definite, and stringent in their specification. I remember reading the proceedings of the Glasgow Housing Committee last year, and some witnesses made very strong objection to the Glasgow building by-laws, because of that. Now the question will arise, What is the best form in which to mould the by-law? Perhaps I may be wrong, but I think in addition to the deliberation of this Committee, we might be assisted by the views of the Institute of British Architects and the Surveyors' Institution, as well as the Burgh Officials' Association of Scotland and the National Plumbers' Association. It seems to me, seeing that we have a clear field before us, as we have no model by-laws in Scotland, we should take this opportunity of appointing a committee and frame a model code for the use of Scottish burghs. In the hope that it will meet with the approval of the meeting, I will move, "That a committee be formed of Scottish Members to consider the formation of a code of by-laws applicable to Scotland."

Mr. Holmes: I have great pleasure in seconding the resolution. The Act of 1903, which came into force in May, requires the framing of by-laws. I think they are very necessary. When you have burghs adjoining each other, difficulties are constantly arising as to house drainage, the trapping of drains, and other matters. If all the burghs could be induced to adopt a uniform system of by-laws, it would be conducive to the general benefit.

Mr. J. Price: As a member of the By-law Committee of the Council, I think the Scottish section of the Association will be wise in adopting the procedure proposed by Mr. Bryce, that is to frame their own by-laws, and not wait until the Local Government Board or some other Government departments make by-laws for them. Unfortunately, in England that is what has happened. The Local Government Board made the by-laws, and we have had to suffer for them ever since. We are trying now to make a set of by-laws which will be workable, which is more than can be said for those we have had in operation in the past. In drawing up by-laws, it is well to make them sufficiently wide, and yet not too wide to be *ultra vires*. All you need is to make by-laws so as to secure that the walls of buildings will be stable, the roofs tight, and the drainage satisfactory. To do more than that is to go beyond your purview. I do not think you will get much assistance from the Royal Institute of British Architects, because many members of that august body either want to make by-laws for themselves, or have none at all. I think the movement you are promoting to-day is one eminently in your own interest.

The resolution was then submitted by the Chairman, and carried unanimously.

Mr. **Bryce**: I propose that the following form the Committee: Messrs. Killop, Lee, Turnbull, Holmes, Young, Ronald, Goudie, Wilson, Winning, and Lumsden.

Mr. **Holmes** formally seconded, and the Committee as proposed was elected.

Mr. J. **Parker**: I should like to propose a vote of thanks to the late Hon. Secretary for the Scottish District, Mr. Dyack. I think one of the most successful meetings which I ever attended, was that held at Aberdeen, and a good deal of the success of that meeting was due to Mr. Dyack.

Mr. **Lumsden**: I have much pleasure in seconding the proposition.

The **Chairman**: I should like personally to endorse the feeling expressed by the mover and seconder of the vote of thanks.

The vote of thanks was then unanimously passed.

Mr. E. G. **Mawbey**: I have pleasure in proposing a very hearty vote of thanks to Mr. Weaver for presiding over us this morning; and for his success in bringing us into one happy fold.

Mr. A. B. **McDonald**: I have pleasure in seconding the proposition.

The vote of thanks was accorded with acclamation.

Mr. W. **Weaver**: I beg to thank you cordially for your kind expression of thanks. It struck me when I was fulfilling the office of President that it would be beneficial to effect the amalgamation which has been consummated this morning. I am quite certain from the feelings which have been expressed this morning that my anticipations will be fulfilled. I may say that the question of holding examinations in Scotland is now receiving the consideration of the Council. I pressed upon the Council of the Association the necessity of holding such examinations to save young men the expense of travelling to attend examinations in England. Examiners will be appointed, and the law paper will be set in Scottish Law.

Mr. **Lee**: I have pleasure in proposing a vote of thanks to the President of the late Scottish Association. Mr. McDonald has not quite completed his term of office, but I think it is the wish of the members of the Scottish Association that before long Mr. McDonald may attain to the position of President of the larger Association.

Mr. **Dawson**: As a Scotsman I have pleasure in seconding the proposition.

The proposition was unanimously passed.

Mr. **McDonald**: I am very much obliged to you. My duties as President have been very light; really the whole of the heat and burden of the day has fallen upon Mr. Bryce.

Mr. McDonald then entertained the Members to light refreshment, after which they proceeded to visit the Glasgow main drainage works at Dalweir; the tidal weir; the waterworks service reservoirs; and the gas works, Dawsholm Station.

MIDLAND DISTRICT MEETING AT BIRMINGHAM.

September 3, 1904.

Held at the Works of the Birmingham, Tame and Rea Drainage Works.

A. T. DAVIS, M. INST. C.E., PRESIDENT, *in the Chair.*

Mr. J. D. WATSON welcomed the Members on behalf of the Chairman of the Drainage Board, who unfortunately was not able to be present that day.

Mr. H. Richardson was unanimously re-elected Hon. Sec. for the Midland District.

The following papers were read and discussed:—

RECENT EXPERIENCE IN SEWAGE AND SLUDGE DISPOSAL AT THE SALTLEY OUTFALL WORKS OF THE BIRMINGHAM, TAME AND REA DISTRICT DRAINAGE BOARD.

BY GEO. A. HART.

THE modifications which have been introduced from time to time into the general method of sewage treatment adopted at the Saltley Works during the last three years appear to have a somewhat interesting bearing in relation to the general question of sewage and sludge disposal, and the Author trusts that, in submitting a short paper on this subject before the Members of the Association, some points of interest may be aroused which will provoke some useful discussion at the subsequent meeting to be held on the works in Birmingham.

Firstly. The Author proposes to submit a brief outline of those engineering features which constitute the works dedicated to the tank treatment of the sewage and disposal of the sludge.

Secondly. To outline the methods of treatment which have been adopted, together with some observations upon the effects caused by the extension of the works and modifications in the character of the treatment.

1. DESCRIPTION.

In 1900 the outfall works then constructed for the tank treatment of the sewage and the disposal of the sludge at Saltley consisted of—First: an installation of three tanks for preliminary treatment of the sewage, called roughing tanks. Each tank averaged 328 feet long by 94 feet wide, and 5·64 feet deep, having a total combined holding capacity of 3,216,100 gallons. Each of the tanks was rectangular in plan, with side walls constructed of brickwork, and had brick-paved floors, having a slight fall lengthways from the outlet towards the inlet end. They were divided into three sub-divisions by cross walls carried up to within 2 feet of the sewage surface. The compartment at the outlet end consisted of one-half of total capacity of each tank, i. e. holding about 500,000 gallons. The remaining two compartments of each tank were of equal size, and held about 250,000 gallons each. Floating scum-boards to prevent the passage of floating refuse, such as corks, etc. were fixed across the inlet end of the tanks.

These tanks received the contents of four main outfall sewers, which are marked upon the plan by the titles of Saltley, Rea, Hockley, and Aston and Handsworth outfalls.

The contributory population to the outfall works was estimated at 707,000, and the average daily dry-weather flow was estimated at 21,000,000 gallons per day.

The sewer inlets entered the tanks at a level of about 3 feet above the floor, and the flow of the sewage was regulated through each of the tanks in parallel. After passing through these preliminary tanks the sewage was conducted into the second installation of tanks, termed finishing tanks. These were also constructed of brickwork, with brick-paved floors, having a fall from the centre line to the inlet and outlet ends respectively.

There were sixteen of these tanks, each measuring 150 feet by 50 feet wide, with an average depth of 6·07 feet, having a total holding capacity of 4,539,500 gallons.

The combined total roughing and finishing tank capacity at the outfall works therefore amounted to 7,755,000 gallons. Sumps were constructed in the floors of the compartment of the tank for the collection of the sludge; they were connected into a well adjoining the tank, in which were fixed bucket elevators driven by shaft and bevel wheel gearing connected to a pair of 20 horse-power steam engines located in an adjoining building.

A Priestman grab attached to a steam crane travelling in a 4 ft. 8½ in. gauge tramway extracted the heavier detritus, which was deposited in tip wagons, and at once removed and tipped in the form of a surplus spoil bank in the immediate vicinity of the works. To supplement the elevators, a steam-force pump was laid down in the engine house, having its suction-pipe connected into each of the tanks.

The sludge from the elevators and pump was delivered into wooden rectangular channels erected upon timber scaffold poles, and which connected the site of the tanks with an area of land restricted to about some 260 acres extending between Saltley and Bromford, on to which the solid and semi-liquid sludge was deposited in the form of lagoons made by stanking up the surface soil.

Early in the year 1902, the outfall works were extended by the addition of two further roughing tanks. They were of similar construction to the tanks previously described, holding about 1¼ million gallons each, and four additional finishing tanks, having each a holding capacity of 680,920 gallons.

No further addition to the tank capacity of the works has since been made.

The total combined roughing and finishing tank capacity at the present time is as follows:—

	Gallons.
Five roughing tanks	5,610,150
Twenty finishing tanks	7,263,180
Total tank capacity	12,873,330

Simultaneously with the increase in the tank accommodation, storm-water filters of an area of half an acre each and containing medium to the depth of 3 feet consisting of screened gas coke, were constructed for the treatment of storm-water conjointly with the tank extensions. The overhead timber sludge shoots were abolished and a cast-iron underground sludge main was permanently laid about 4 feet deep, extending from the outfall works for a distance of 2½ miles through the farm-lands to Castle Bromwich.

Manholes were constructed along the main containing branch sluice outlets at intervals of 210 yards; these outlets were arranged with several pipe connections on to the surface of the ground, so that temporary pipe connections can be laid therefrom to the highest points in the various fields which are about to be sludged.

New buildings were erected containing two Lancashire boilers, each 30 feet long by 8 feet diameter, and the existing engines were rearranged and connected to a pair of belt-driven air compressors, which supplied compressed air to a series of four Shone's pneumatic ejectors, which were connected with the cast-iron sludge main.

Two additional sludge pumps were installed in the engine-house for the purpose of extracting the sludge from each of the tanks.

The delivery branches of the pumps are arranged so that the sludge may be delivered either directly through the sludge main to the land or into an elevated sludge tank for the filling of the ejectors.

The complete sludge plant is equal to the duty of discharging 30,000 gallons of liquid sludge per hour—containing an average of 10 per cent. solids—through 2½ miles of 9-inch cast-iron main.

To dispose of the supernatant water in the tanks, two direct driven centrifugal pumps were installed in the engine-house having the delivery connected into the main outfall carrier. Each of these pumps is capable of pumping off the supernatant water from one tank in about eight hours.

2. Treatment.

From the year 1872 to February 1901, the general system of sewage treatment at the works consisted of chemical precipitation, followed by subsequent sedimentation in the two installations of tanks termed roughing and finishing tanks, the final tank effluent being subsequently treated on land.

The storm water was treated conjointly with the sewage, and after passing through the combined tanks was discharged over intercepting overflow weirs into the river.

The chemical re-agent consisted of finely ground lime added to the crude sewage in the form of milk of lime in the proportion of twelve grains to the unit gallon. The cost of the lime treatment amounted, in the year 1900, to 4332*l.*, which is equivalent to a cost of 11*s.* 6*d.* per million gallons of sewage treated.

The amount of detritus and the volume of sludge extracted from the roughing and finishing tanks during the last ten years of lime treatment was as follows:

Year.	Estimated daily Dry Weather Flow, in gallons per 24 hours.	Volume of Liquid Sludge 90 per cent. Water, in cubic yards.	Solid Detritus 50 per cent. Water, in cubic yards.
1891	19,000,000	235,427	5,000
1892	19,200,000	232,762	4,505
1893	19,400,000	256,119	5,581
1894	19,600,000	239,571	7,288
1895	19,800,000	262,958	8,432
1896	20,000,000	281,443	9,249
1897	20,250,000	316,878	9,205
1898	20,500,000	346,129	10,354
1899	20,750,000	264,423	14,616
1900	21,000,000	169,468	10,246

The composition of the various sewages contributed to the outfall works by the four main outfall sewers is very varied, trade effluents constituting a very considerable proportion, derived mainly from the metal and hardware trades, and the presence of ferrous salts forms a marked feature in the composition of the resulting sewage.

The following tables of analyses of the constituent crude sewages contributed to the outfall works by the four main outfall sewers, having been taken over a period of three years, may be said to be generally representative.

CRUDE SEWAGE, YEARS 1901, 1902 AND 1903. TABLE OF ANALYSES.

1901. *Results expressed in parts per 100,000.*

Dissolved Solids	Suspended Solids.	Free and Saline Ammonia.	Albuminoid Ammonia.	Chlorine.	Nitrogen as Nitrates and Nitrites.	Oxygen absorbed.		Alkalinity.	Total Nitrogen.		Nature of Sample.
						Unfiltered	Filtered.		Unfiltered	Filtered.	
145·5	73·5	4·16	1·56	12·5	0·30	13·43	5·67	18·6	8·07	6·43	Saltley sewage
134·0	54·6	3·50	1·52	24·5	0·33	17·38	10·26	18·2	8·33	6·55	Rea sewage
145·1	70·4	3·87	1·67	21·6	0·89	14·04	5·49	0·5	9·34	7·21	Hockley sewage
94·8	88·4	5·17	1·95	12·1	0·12	13·33	5·50	22·4	9·45	6·79	Aston sewage
129·1	67·6	3·87	1·66	20·3	0·44	15·32	7·61	..	8·84	6·78	Computed average sewage

Saltley.—The Saltley sewage is chiefly domestic; its flow represents 7 per cent. of the total volume.

Rea.—The Rea sewage is of a very mixed nature, and contributes about 43 per cent. of the total flow.

Hockley.—The Hockley sewage has a very low alkalinity, but free acid has not recently been observed; it contains a large percentage of trade refuse from the iron and brass industries, and contributes 27 per cent. of the total dry-weather flow.

Aston and Handsworth.—The Aston and Handsworth sewage is in bulk domestic, and contributes about 23 per cent. of the total flow.

The lime treatment was originally adopted to precipitate the suspended solids and to counteract the effect of the ferrous salts contained in the sewage.

The sludge deposited in the first bays of the roughing tanks consisted principally of gritty matter, containing also a percentage of vegetable refuse intermixed with it. A dried sample had the following analysis:—

	Per cent.
Volatile and organic matter	44·95
Sand and insoluble matter	44·54
Other inorganic matter.	10·51
Total	100·00

Containing nitrogen 1·43 per cent.

CRUDE SEWAGE, 1902 AND 1903. TABLE OF ANALYSES.

Results expressed in parts per 100,000.

Nature of Sample.	Dissolved Solids.	Suspended Solids.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Nitrates, etc., as Nitrogen.	Oxygen Absorbed in 4 hours.
1902.							
Saltley sewage	139·0	51·6	5·29	1·14	12·0	·44	12·78
Rea „	136·4	66·2	4·77	1·84	28·7	·94	28·00
Hockley „	147·4	60·2	4·31	1·74	24·8	·82	15·03
Aston „	120·6	89·5	5·19	1·67	17·3	·17	14·41
Computed average sewage . .	127·6	68·6	4·77	1·73	21·8	·70	18·22
1903.							Oxygen Absorbed.
Saltley sewage	142·9	55·3	3·116	·960	12·3	·732	20·843
Rea „	127·3	60·6	2·916	1·309	21·5	·816	23·998
Hockley „	124·9	62·3	2·730	1·166	20·5	·908	25·366
Aston „	107·8	120·0	3·061	1·479	16·1	·793	23·387
Computed average sewage . .	123·5	73·6	2·910	1·283	19·4	·831	24·024

In its normal condition it contains about 50 per cent. of water; when allowed to air-dry it assumes the form of a stiff hard cake.

The liquid sludge intercepted in the tanks consists of 90 per cent. of water; it rapidly assumes a black appearance, and when dry has the following analysis:—

ANALYSIS OF DRIED SLUDGE.

	Per cent.
Volatile and organic matter	56·53
Sand and insoluble matter	29·12
Other inorganic matter	14·35
Total	100·00

Containing nitrogen 2·59 per cent.

When allowed to air-dry it assumes the form of a light porous friable cake.

The sewage and storm-water were together passed through the roughing tanks, which were emptied as soon as they gave indication of having become filled with sludge. The cleaning of one of these tanks under this method frequently occupied from seven to ten days, and the effective tank capacity available for sewage did not generally exceed one-third of the total capacity, the remaining tank capacity being monopolised by deposited sludge and detritus.

Owing to the length of time that the detritus and sludge were allowed to accumulate in the tanks, the exposure to the air of the sludge, when cleaning the tanks, caused by the running off of the supernatant water, was invariably accompanied by the evolution of organic gases and bad smells.

On account of the rapid increase in the volume of sludge precipitated by the liming process, it was decided to entirely suspend the liming of the sewage and to commence the promotion of bacterial action in the tanks.

It was predicted that it would be practicable, by adopting a method of frequently and rapidly removing from the roughing tanks the sludge as it was deposited, to counteract the effect of some of the acidified discharges of sewage which periodically pass down to the works by increasing the effective tank space, and that an important advantage anticipated by the promotion of septic fermentation would be a reduction in the volume of sludge produced in the tanks together with a saving in treatment at least amounting to the cost of the unslaked lime. To counteract this advantage it was anticipated that the tank effluent resulting from bacterial action and sedimentation would contain a much larger quantity of suspended matter than the chemically precipitated effluent had hitherto produced, and some anxiety was felt as to the result of the application of the unlimed tank effluent upon subsequent land treatment; and it is satisfactory to be able to say that as the result of a further investigation upon this point extending over the last three years it has been established that the land effluents have shown annually a gradual improvement.

On the albuminoid ammonia and oxygen absorbed bases, in terms of percentage of purification upon crude sewage, this improvement is indicated by the following figures:—

	Albuminoid Ammonia Basis.	Oxygen absorbed Basis.
	Per cent.	Per cent.
1901	88	88
1902	92	90
1903	92	93

The effect of the change in treatment from chemical precipitation to septic fermentation in the volume of sludge arrested in the tanks justified anticipation. As a result of fifteen months' observation it may be stated that the reduction in volume of the sludge deposited in the tanks amounted to 58 per cent. of the total bulk, expressed in terms of cube yards of sludge per million gallons of dry-weather flow. The figures are as follows:—

	Cubic Yards.
Lime treatment	35·55
Septic treatment	14·85

This method of treatment was consistently followed out until March 1903, but a disturbing element, which had an appreciable effect upon the treatment, was introduced in 1902 by the addition of two extra roughing tanks and four finishing tanks.

This additional tank accommodation, representing an increase of 66 per cent., increased the volume of sludge deposited in the tanks by 22 per cent., making the total volume of sludge deposited per million gallons of dry-weather flow amount to 18·20 cubic yards.

Simultaneously with the increased tank accommodation, a storm-water weir was constructed in the roughing tank effluent channel. The combined sewage and storm-water is now treated together in the five roughing tanks; the storm-water, after sedimentation, being automatically diverted over the storm overflow weir for subsequent treatment on straining filters before its final passage into the river Tame.

In April 1903 the new sludge disposal plant which had been constructed with the object of rapidly and effectively removing the sludge to a more distant site, thereby increasing the effective roughing tank capacity, was brought into operation, and the method which had up to that time been adopted of allowing the sludge to accumulate in the roughing tanks until they gave evidence of becoming filled with sludge, was superseded by a method involving the cleaning of one tank per day.

The supernatant water is decanted and pumped off from one tank during the night; this operation mainly occupies from eight to ten hours. The sludge accumulated in the tank generally occupies a space of about 18 inches deep, and is scraped down as rapidly as possible by seven tank men with wooden scrapers into the sludge sump connected with each tank. The sludge is drawn out simultaneously by the sludge pumps in about six hours and forced through the sludge main on to the land for treatment.

In its passage from the tank into the sludge suction chamber the sludge is passed through an iron screen of about 1¼-inch mesh to which is attached a revolving rake which effectively extracts from the sludge the cloths, rags, and similar fibrous material.

The discharge from the rake is tipped direct into wagons and removed to a spoil tip or destroyed in the boiler furnaces.

This method has proved most effective; its chief recommendation being that in lieu of a large quantity of elaborate screening machinery which would be required if this comparatively small percentage of fibrous material were extracted from the crude sewage, it has been found quite practicable to allow the material to deposit itself and to remove it in bulk in a comparatively short time; the whole of one week's sludge being effectively screened and removed from each tank in about six hours. By this method of tank cleaning, the resulting sludge is never exposed to the action of the air for more than about six hours, and the rapid removal of the sludge from the tanks has been found most effective in preventing the evolution of the bad smell which almost invariably accompanies the decomposition of organic substances when exposed to the atmosphere.

The average volume of liquid sludge removed per day from the tanks for the past thirteen months of this method of cleaning amounts to 590 cubic yards per day on an estimated dry-weather flow of 22,000,000 gallons per twenty-four hours, which is equivalent to 26·22 cubic yards per 1,000,000 gallons treated. The effect produced by this system of frequent cleaning was to increase the volume of liquid sludge deposited in the roughing tanks by 44 per cent. Another important feature resulting from this operation was the effect produced upon the heavier solids consisting mainly of insoluble and inorganic material, which when deposited in the tank and allowed to remain there for an extended period, as had been the case hitherto, became so dense that it was found impracticable to remove them except by means of a dredger.

As a result of the more frequent cleaning of the tanks it was found quite practicable to reduce the bulk of this residual detritus, by carefully mixing during the process of cleaning the heavy gritty material with the lighter sludge in a marked degree; so much so that a decrease of 50 per cent. was obtained in the volume of the material; it has been found impracticable to remove the residue in a fluid form through the sludge.

Under the old system of cleaning, this detritus averaged 28 cubic yards per day, being at once reduced to 12 cubic yards per day.

This material being largely inorganic, and consisting mainly of road grit, is highly beneficial to the sludge when dug into the ground, and as the result of some 15 months' working in this form it may be stated that the average volume of solid material which it has been found impracticable to mix through the sludge, and has therefore to be removed from the tank in dry and solid form, does not exceed 12 cubic yards sludge per day on a dry-weather flow of 22,000,000 gallons.

The liquid sludge is now trenched into ground which is chiefly of a light and porous character, which has been sub-soil drained, and extending from Bromford Bridge to Castle Bromwich.

The area of ground which is embraced by the existing sludge main covers 365 acres, and, based upon the volume of sludge deposited at the outfall works at the present time, it is computed that an acreage of ground amounting to 80 acres per annum is entirely monopolised by sludge trenches.

Under the most favourable climatic conditions it is advisable to allow the sludge deposited in the trenches a rest of at least two years before it is sufficiently decomposed and disintegrated that it may be taken and used for re-sludging.

At the present time it may be stated that the area of land which is dedicated to the disposal of the sludge produced at the outfall works amounts to about 240 acres, which is equivalent to a three years' cycle of 80 acres per annum.

The present method of trenching the sludge into the ground consists in excavating the ground in a series of long parallel trenches 3 feet wide by 18 inches deep, the space between each trench being left 3 feet wide. The excavated material is thrown up in the form of a rampart between each trench, making a total available depth of 3 feet.

A large main trench is formed at right angles to the subsidiary trenches into which the liquid sludge is pumped from the outfall works.

The supernatant water and thin sludge are first run into the trenches and allowed to fill the lower ends, the thicker material following in after the greater part of the water had become absorbed in the sides of the trenches. Small earthen ramparts are left in the trenches at regular intervals of about 20 yards for the purpose of intercepting the solids, and allowing the supernatant water to run off in front.

In about three days after the filling of a trench it is usually sufficiently consolidated to admit of a light covering of screened soil about 1 inch deep being spread over the surface, and after a subsequent interval of about ten days for further consolidation the bulk of the sludge has generally settled down to about one-half of its original depth and volume, and is sufficiently solid to allow of the balance of the excavated material being filled into the trenches.

In the course of a few weeks it is generally found practicable to excavate intermediate trenches from the solid ground which was originally left between the lines of the first trenches.

Stiff land is not well adapted for the trenching of sludge; where it has been used it has been found impracticable to cover in the filled-in trenches within reasonable time, occasionally extending to several weeks owing to the liquid being unable to percolate through the sides of the trenches.

In hot and dry weather it is absolutely essential, if smell is to be avoided, that the sludge should be covered in from the atmosphere, and, failing this, some means found to counteract the evil-smelling odour arising from the decomposition of the organic matter in the sludge. During a recent spell of hot and dry weather, a solution of bleaching powder containing hypo-chlorite of calcium, having 36·35 per cent. of available chlorine, was added to the sludge at the outfall works, experimentally as a deodoriser, in the proportion of 35 lb. by weight of solid powder to 20,000 gallons of sludge.

It has been demonstrated that the chlorine which was evolved from the mixture counteracted in some small degree the effect of the odours arising from the exposed sludge.

It is anticipated that the action of the bleaching powder will be somewhat detrimental to the propagation of vegetable growth, but this is purely a temporary disadvantage, as it is predicted that the effect of the hypo-chlorite upon the soil will not be a permanent one.

The propagation of septic fermentation in the finishing tanks together with the frequent cleaning of the roughing tanks was continuously followed for a period of thirteen months. As the result of observations taken during that period it was conclusively established that. although the efficiency of the roughing tanks for sedimentation had been increased 44 per cent., the septic tanks gave unmistakable evidence of becoming inert. It appears to be a speculative question as to why this should have occurred.

The most reasonable theory which the Author can put forward to account for this phenomenon is to the effect that the increase in the effective roughing tank capacity produced such a degree of sedimentation that the greater bulk of the organic substances containing the fermentative organisms necessary to promote septic action were deposited as sediment in the roughing tanks, and the finishing tanks were therefore deprived of the elements upon which their septic action depended.

To remedy this defect, in May 1904, directions were given that the whole of the lighter organic sludge which was deposited daily in the roughing tanks should be pumped into the septic tank inlet channels. The quantity of sludge thus transferred from roughing to finishing tanks, has been gradually increased during the last three months, and at the present time a volume equal to 30 per cent. of the total sludge deposited is daily passed into the septic tanks. There has been no indication that the finishing tanks have attained their ultimate efficiency; the fermentative action was almost immediately restored and is being gradually increased month by month.

It will not be practicable at the present time to indicate as to how far this condition may be further established, as the publication of these observations is contemporaneous with the final results indicated.

It is interesting to observe that, as a result of 3½ years' continuous septic fermentation in the finishing tanks, extending from March 1901 to May 1904, the residual products deposited therein during that period, and which it has been deemed advisable to remove therefrom in the form of sludge, has only amounted to the volume of 25,000 cubic yards, that is a volume equal to half the holding capacity.

An analysis of the residuum deposited in the tank is as follows:—

	Per cent.
Volatile and organic matter	42·30
Sand and insoluble matter	18·60
Other inorganic matter	39·10
Total	100·00

Total nitrogen in above, 2·80 per cent.

The septic residuum was deposited on land in a layer of about 15 inches deep. It gave rise to no offence, no smell has been detected arising therefrom, and after lying open and exposed to the action of the atmosphere for six months and being ploughed over, it would be difficult now to differentiate between the appearance and characteristics of natural surface soil and this material.

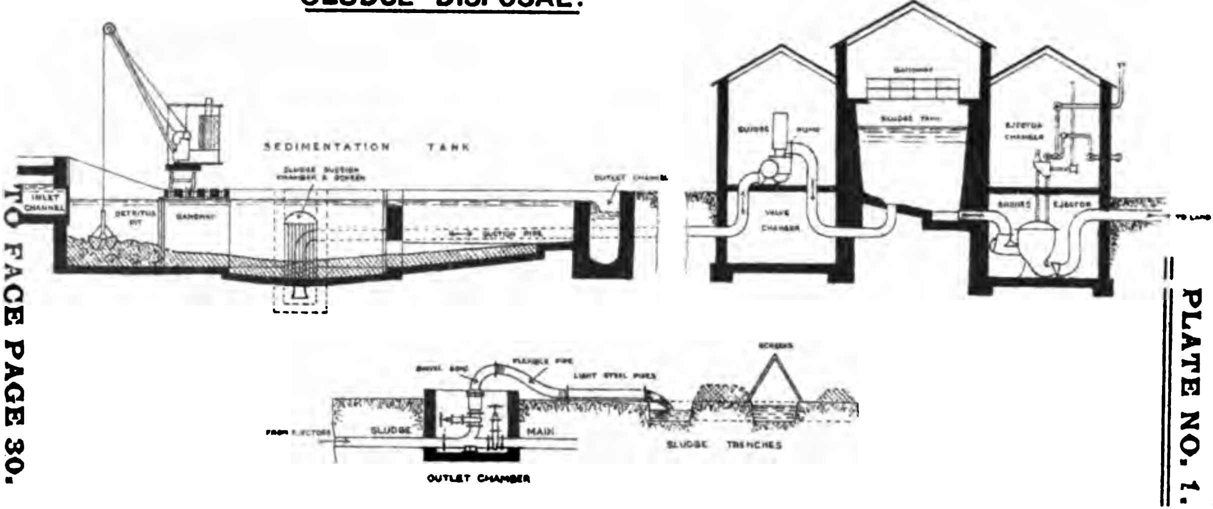
There appears to be some foundation for the belief that many of the very real difficulties which attend the removal and disposal of sewage sludge may be alleviated by judicious tank treatment, and it appears to be equally essential that the utmost care and regard should be given to detail in the application of the treatment, and to the design of those works dedicated to the various functions embodied in the treatment if results of an efficient and generally satisfactory kind are to be produced.

To amplify the description and observations, a table is

PLATE NO. 1.

BIRMINGHAM TAME & REA DISTRICT DRAINAGE BOARD,

DIAGRAM ILLUSTRATING METHOD OF SLUDGE DISPOSAL.



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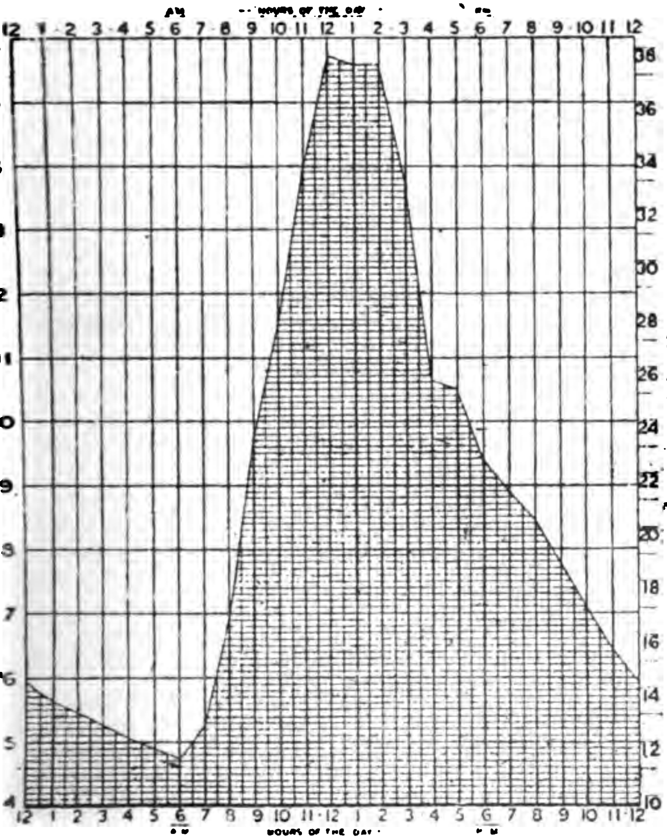
"PHOTO-LITHO" R. J. EVERETT & SONS. 19, BARTLETTS' BUILDINGS. HOLBORN CIRCUS. E. C.

BIRMINGHAM, TAME AND REA DRAINAGE BOARD.

PLATE II.



Hourly Variation in Rate of Dry Weather Flow at Outfall Works.

attached to this paper, embodying the results of the five distinct periods in the modification of the sewage and sludge tank treatment, which the Author believes will assist to some degree in focusing the cardinal facts so that they may be readily compared.

In conclusion, the Author desires to express his best thanks to Mr. Watson, the engineer, for the opportunity he has given to him of laying these observations before the President and Members of the Association, and to the chemist (Mr. O'Shaughnessey) and other gentlemen who have so kindly assisted him in the preparation of the contents, which the Author trusts may have afforded some little interest to those both directly and indirectly connected with the problem of sewage purification.

Statement of the Average Yearly Current Expenses occasioned by the Treatment of the Sewage by Chemical Precipitation with Lime and Disposal of the Sludge.

	£.	s.	d.
Cost of precipitation and chemicals on an average dry-weather flow of 20,000,000 gallons per day . .	4,332	9	5
Cost of power used in raising sludge from tank and depositing on land 259,512 yards at ·63*d.* per cubic yard	681	4	5
Materials and labour in tank cleaning at ·571*d.* per cubic yard	617	8	5
Stanking and trenching into land at 1·6*d.* per cubic yard	1,730	1	7
8,496 cubic yards of detritus removed from tank by grab at 1*s.*	424	16	0
Total annual cost of sludge disposal during liming operations at 7·2*d.* per cubic yard	£7,785	19	10

Statement of the Average Yearly Current Expenses occasioned by the Treatment of the Sewage by Sedimentation and Septic Fermentation.

	£.	s.	d.	£.	s.	d.
Labour in tank cleaning:—						
Workmen's wages . . .	574	12	0			
Clothing, tools, etc. . . .	20	0	0			
				594	12	0
Working expenses of steam plant and attendance:—						
Engineers and stokers . .	132	12	0			
Oil, waste, etc. . . .	13	0	0			
Coal	510	6	0			
				655	18	0
Trenching into ground and covering in . .				1,666	13	0
8,500 cubic yards detritus removed by grab and taken to tip at 1*s.*				175	0	0
Total annual cost of removal and disposal of 250,000 cubic yards of sludge by existing method (equivalent to 2·968*d.* per yard)				£3,092	3	0

TABLE SHOWING RESULTS OF THE ALTE

Period.	Treatment.	Average Dry Weather Flow, in gallons per day.	Crude Sewage, in parts per 100,000.		Roughing Tanks.									
					Capacity in gallons.	Period of Sedimentation.						Rate of Flow.		
						Maximum		Minimum		Mean.		Max.	Min.	Mean.
			Dissolved Solids.	Suspended Solids.		hr.	min.	hr.	min.	hr.	min.	ft. per min.	ft. per min.	ft. per min.
From Jan. 1891 to Feb. 1901 inclusive (122 months).	Chemical precipitation and subsequent sedimentation.	20,000,000	129·1*	67·6*	3,216,000	7	30	2	15	3	50	2·4	0·66	1·33
From Mar. 1901 to May 1902 (15 months).	Sedimentation and subsequent septic treatment. Finishing tanks used as septic tanks.	21,500,000	128·3	68·1	3,216,000	7	00	2	4	3	30	2·6	0·71	1·43
From June 1902 to Mar. 1903 (10 months).	Sedimentation and septic treatment with increased tank capacity.	22,000,000	126·3	70·1	5,610,150	11	40	3	30	6	10	1·5	0·44	0·85
From Apr. 1903 to Apr. 1904 (13 months).	Same as previous period, with more frequent cleaning out of roughing tanks.	22,500,000	120·2	69·0	5,610,150	11	20	3	25	6	00	1·47	0·45	0·87
From May 1904 to July 1904 (3 months).	Same as previous period, but portion of liquid sludge removed from roughing tanks pumped into septic tanks.	22,500,000	120·2	60·0	5,610,150	11	20	3	25	6	00	1·47	0·45	0·87

* These figures are the results of analyses extending over the last twelve months of the period.

† This figure represents amount of sludge taken from roughing and finishing tanks combined.

‡ Figure showing cube yards of sludge per 1,000,000 gallons of dry weather flow pumped from roughing tanks into finishing tanks (septic tanks).

TANK TREATMENT OF SEWAGE AND SLUDGE.

	Roughing Tank Effluent, in parts per 100,000.		Finishing Tanks.										Finishing Tank Effluent, in parts per 100,000.		Proportion of Total Suspended Solids Arrested in Roughing Tanks, per cent.	Proportion of Total Suspended Solids Arrested in Roughing and Finishing Tanks Combined, per cent.	Rainfall Average per Month, in inches.
			Capacity in gallons.	Period of Sedimentation.						Rate of Flow.							
				Maximum.		Minimum.		Mean.		Max.	Min.	Mean.					
[illegible]	Dissolved Solids.	Suspended Solids.		hr.	min.	hr.	min.	hr.	min.	ft. per m'n.	ft. per min.	ft. per min.	Dissolved Solids.	Suspended Solids.			
[illegible]	138·0*	16·3*	4,539,500	10	27	3	9	5	30	0·80	0·24	0·45	133·2*	4·2*	75·9*	94*	2·107
[illegible]	128·7	29·6	4,539,500	9	37	2	54	5	05	0·86	0·26	0·48	116·6	25·9	56·5	62	1·974
[illegible]	125·9	28·69	7,263,180	15	00	4	35	8	00	0·54	0·17	0·31	113·7	23·2	50·0	67	2·437
[illegible]	109·3	16·8	7,263,180	14	40	4	30	7	50	0·55	0·173	0·32	103·7	13·1	75·6	80	2·710
[illegible]	114·7	20·0 12·0§ 32·0	7,263,180	14	40	4	30	7	50	0·55	0·173	0·32	112·3	21·6	66·7‖	65	1·738

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§ This figure represents the average extra amount of suspended solids added to roughing tank effluent due to the pumping of sludge from the roughing tanks.

‖ The actual sedimentation of 66·7 per cent. is reduced to an effective sedimentation of 46·7 per cent. due to the pumping of 30 per cent. of the total sludge into the finishing tanks.

DESCRIPTION OF THE PURIFICATION WORKS IN COURSE OF CONSTRUCTION AT MINWORTH GREAVES.

BY A. BRYAN, RESIDENT ENGINEER.

GENERAL DESCRIPTION OF SITE.

THE works being constructed by the Birmingham, Tame and Rea District Drainage Board for the bacterial purification of sewage, are situated in the district of the borough of Sutton Coldfield, and are distant some five miles from the Outfall Works at Saltley.

The main considerations which led to the adoption of this site are briefly as follows :—

It is removed from large centres of population, and not likely to be affected by the encroachment of suburban districts.

The natural level of the ground gives ample head for constructional work, which is probably one of the greatest difficulties with which sanitary engineers have to contend in designing works of this description.

The main supply conduit traversing the farm is laid with an hydraulic gradient of 2 feet per mile, whilst the river Tame falls about 9 feet per mile; this gives at the site of the works a net available head of some 36½ feet; the water level in the silt tanks being 275·5 O.D. and the invert of the main effluent channel 239 O.D.

The site being at the extremity of the main conduit enables the septic action begun at Saltley to be continued, and as the capacity of the conduit is some 6,000,000 gallons, an appreciable area of septic tank room is saved.

Deep sedimentation tanks can be constructed at such levels as will admit of their being syphoned out.

The construction of the primary beds does not entail a large amount of excavation to utilise the head available.

The subsoil of the secondary beds is of sand and gravel, which is being used for constructional purposes and for medium.

The surplus excavation is utilised for filling up low lying land in the near vicinity, which is subject to floods in wet weather.

The boundaries of the site are skirted by a canal and railway, which give facilities for cheap carriage of materials, an important feature in works of this magnitude.

The subsidiary works in connection with the scheme include a canal wharf to allow of six boats being unloaded at one time, a railway siding for eight trucks, and a length of 4000 yards of narrow gauge tramway.

DESCRIPTION OF WORKS.

The works in course of construction comprise:—

1. An intake chamber to form the connection between the existing main supply conduit and the new works, in which is fixed an apparatus for automatically regulating the flow of sewage, so that in dry weather a constant volume will be delivered to the bacteria beds.
2. A series of silt or sedimentation tanks to remove the suspended and floating matter present in the septicised sewage.
3. An installation of primary percolating beds to effect a partial purification of the sewage.
4. The provision in the main effluent channel from the primary beds of a sedimentation tank to arrest the humus in the filtrate.
5. An installation of secondary percolating beds to complete the work of purification in the event of land not being available for the purpose.

INTAKE CHAMBER.

The connection to the existing main supply conduit, which at the site of the works is an hydraulic main 54 inches in diameter, was made by cutting out a length of pipe and inserting a 42-inch on 54-inch junction pipe.

The existing 54-inch pipe was cut by drilling holes ½ inch in diameter, spaced at 1½-inch centres round the circumference. This was done whilst the sewage was flowing, the holes being plugged with hard-wood plugs. The sewage was then shut off, the metal between the holes cut with chisels, and the pipe broken with a heavy weight, after the manner of a pile-driver, and forced off with drifts. This operation was carried out during the August holidays when the flow of sewage was small. The junction and the making up length of pipe were inserted, and the joints made good with double collars run with lead, and caulked inside with rust cement.

A 42-inch diameter sluice-valve was then bolted to the junction, which enabled the sewage to be turned on and the remainder of the connection made at leisure. This work was successfully carried out by the contractor after sixty hours' continuous work.

The intake chamber consists of an inlet sump, in which is fixed an hydraulic penstock, 42 inches in diameter, forming part of an apparatus for automatically regulating the flow of sewage, and a rack and worm penstock, 42 inches in diameter, which will be used when the water supply actuating the hydraulic penstock is shut off.

An overflow weir, 9 feet in width, is constructed in the upper part of this chamber, over which, in times of storm, an excess volume of diluted sewage will be passed to the beds.

The sewage passes through the hydraulic penstock into a large gauging-pond, in which its velocity is checked before it passes over the main regulating weir of the apparatus.

A portion of this chamber is enclosed to afford protection to the float and adjusting mechanism; the sewage flows over the weir into the outlet bay, and thence to the silt tanks.

Wash-out valves, emptying into the silt main, are provided for cleaning out the various chambers.

The level of the sewage in the main supply conduit, which is 8 feet in diameter, varies some 5 feet to 6 feet during the 24 hours, and some means were necessary to ensure that in dry weather a uniform volume should pass to the beds.

After a careful consideration of schemes involving the use of floating arms, both vertical and horizontal, sluices opening in proportion to the head of water, etc., an apparatus designed by Messrs. Dodd and Dodd, of Birmingham, was adopted as being the most suitable for the purpose.

Dodds' Apparatus.—The principle of the apparatus may be briefly described as follows:

The variation in the height of water flowing over a weir raises or depresses a float, which sets in motion the piston of a regulating valve, controlling the water supply to an hydraulic cylinder, and which in turn opens or closes a penstock fixed on the main sewer.

The piston of the hydraulic cylinder is coupled directly to the 42-inch penstock, the working areas above and below the piston being 80 square inches and 36 square inches respectively, by which means about one-half of the quantity of water otherwise requisite to work the apparatus is saved, as only the water admitted to the top of the piston is discharged through the exhaust pipe.

The water supply for working the apparatus is obtained from the public water service under a pressure of about 100 lb. per square inch.

The supply of water to the cylinder is controlled by a small regulating valve or cylinder, fitted with piston valves having a stroke of $\frac{1}{8}$th of an inch, worked by means of a copper float 3 feet in diameter, the arms of the connecting lever being in the ratio of 2 to 1, so that a variation exceeding $\frac{1}{16}$th of an inch above or below the normal height of water flowing over the weir for the volume required is sufficient to set the apparatus in motion. The float in consequence rises or falls, and operating the regulating valve allows water to be admitted to the hydraulic cylinder, which opens or closes the penstock as the case may be.

Should the volume, due to the small depth in the main sewer, be less than that which the apparatus is adjusted to pass, the penstock remains open.

A pointer, working in connection with an indicator plate, is fixed to the float rod; the indicator plate will be graduated in place with the depth of water flowing over the weir corresponding to the various volumes required, and the calculated heights will be checked by direct measurement of quantities passed into the silt tanks during observed periods.

In setting the apparatus to deliver any desired volume, the piston of the regulating valve is fixed in a central position by means of a handle and pin, and the float adjusted to the height marked on the indicator plate by means of a thumb-screw on the float rod; the piston is then released and the apparatus is ready for work; an easy and accurate means of passing any desired volume of sewage to the bacteria beds is thus ensured.

The sewage from the intake chamber flows through cast-iron pipes, ranging in diameter from 42 inches to 24 inches, into the silt tanks.

SILT TANKS.

The silt tanks are five in number, and are of the type known as Dortmund tanks.

They are 44 feet in diameter, and 33 feet 6 inches deep from coping level to the bottom of the sump, the lower portion being in the form of an inverted cone, having a batter of 1 to 1.

The subsoil is of stiff red marl, with thin veins of magnesium limestone, and the excavating was carried out without the use of timbering, the water leaking into the tanks being kept down by the occasional use of an ordinary hand pump.

An annular trench was first excavated, and the concrete foundation for the vertical walls put in place, the walls, which are of brindle brickwork, set in cement mortar, were then carried up, the central core and conical portion excavated.

The concrete lining of the lower part is 2 feet in thickness, and was put in place in layers without the use of sheeting, and rendered with cement mortar.

The collecting channels have been designed on somewhat different lines to the usual method; it being found that, owing to the tanks being of necessity above ground level, the ordinary collecting channel round the circumference would be costly, and, moreover, some support would be necessary for the inlet pipe, and to afford means of access to the cleaning out branch of the vertical silt pipe.

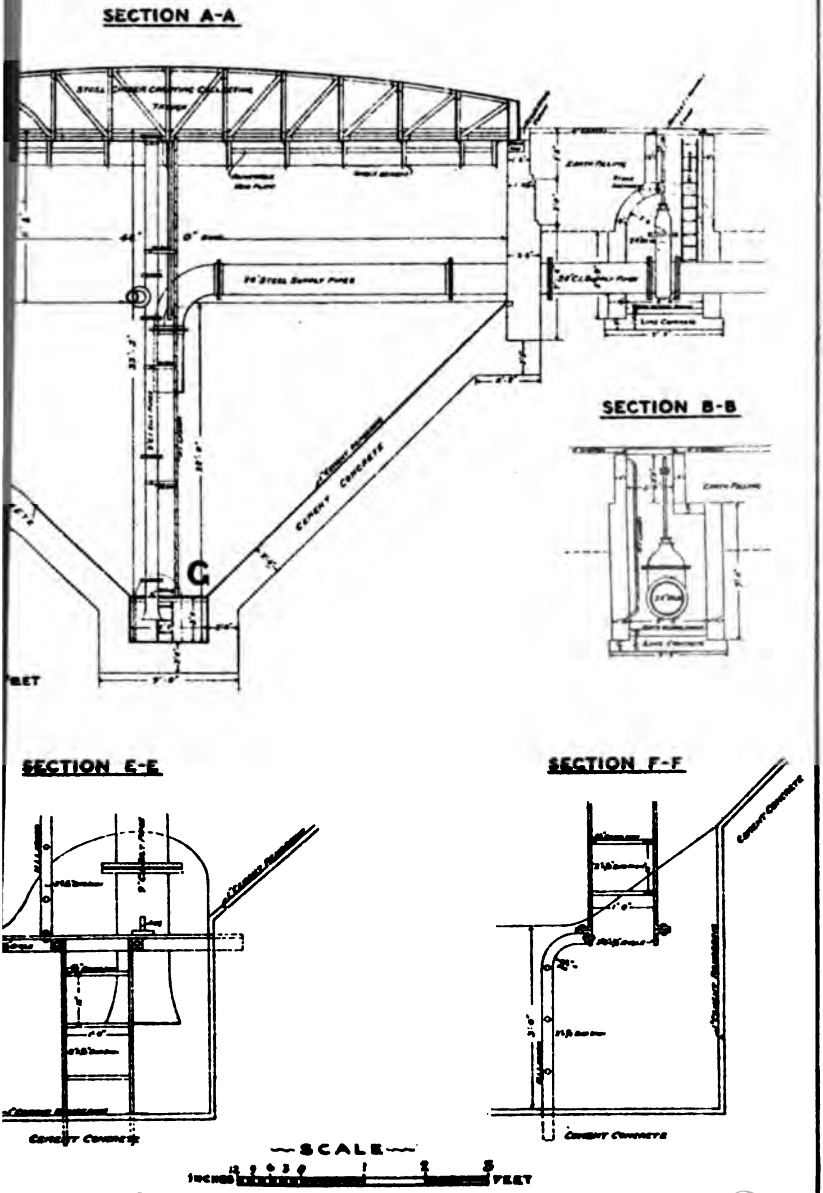
The collecting trough is, therefore, designed to be suspended from girders spanning the tanks.

The girders are of the ordinary hog-back type, with side gangways carried on cantilevers, and have a total length of 45 feet 6 inches, the depth at the centre being 4 feet 9 inches, and at the ends 2 feet 6 inches.

The main flanges are formed of 3½-inch by 3½-inch by ⅜-inch angles, the verticals of 2½-inch by 2½-inch by $\frac{5}{16}$-inch angles, and the tension bars and cross bracing of 2½-inch by $\frac{5}{16}$-inch bars.

The collecting trough is of $\frac{5}{16}$-inch plate, and is supported

PLATE NO. 1.



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"PHOTO-LITHO." R.J. EVERETT & SONS. 19, BARTLETTS' BUILDINGS, HOLBORN CIRCUS. E.C

on $2\frac{1}{2}$-inch by $2\frac{1}{2}$-inch by $\frac{3}{8}$-inch angle frames secured to 4-inch by 3-inch by $\frac{3}{8}$-inch angle bearers riveted to the lower flange of the girders; on these bearers are also fixed the joists supporting the gangways, which are of 9-inch by 3-inch creosoted red deals.

The trough is fitted on each side with adjustable weir plates 3 inches by $\frac{5}{16}$ inch, having a total length of about 70 feet.

Provision is made to retain any scum and floating matter by means of scum-plates 1 foot 9 inches deep, fitted between the cantilever brackets.

The tanks are protected with a handrail, and fitted with vertical ladders extending from the girder to the bottom of the sump.

The trough is connected to the pipes supplying the beds with steel bends 18 inches in diameter.

The inlet pipes are formed of riveted steel pipes 24 inches in diameter, suspended from the girders by means of angle straps.

Although a number of these tanks have been constructed in this country, no information was available as to the most suitable depth to take the inlet pipes; they have, therefore, been made temporarily of various lengths, varying from 15 feet 9 inches to 19 feet 9 inches below water level, and will be shortened or otherwise in accordance with the results obtained from the working of the different tanks.

The silt accumulating in the sump and the lower part of the cone will be forced through the vertical leg of the silt pipe under a pressure of 10 feet head of water and discharged on to the farm lands through a 12 inch cast-iron silt main 1350 yards in length.

The silt main is of cast-iron pipes and will be utilised to syphon out the tanks in case they require emptying, the outlet being at such a level as will admit of this being done to within a few feet of the bottom, and leaving only a small quantity to be dealt with by pumping.

The combined cubic capacity of the five tanks is 807,000 gallons.

The normal flow is 42,000 gallons per hour, which gives an upward velocity through the cylindrical portion of the tank of 4·4 feet per hour, and a period of sedimentation of 4 hours.

The sewage passes from the silt tanks to the bacteria beds through a system of cast-iron pipes, varying in size from 36 inches to 21 inches in diameter.

EXPERIMENTAL BEDS.

An installation of 1½ acres of single percolating beds, and which may perhaps be termed "experimental beds," has been constructed and is now at work.

The beds are five in number; four of these, known as the "A, B, C and D" beds, are circular, each having an area of ¼ acre; the remaining bed "E" is of the rectangular type and ½ acre in extent.

The circular beds are constructed wholly above ground level, and are 120 feet in diameter, the average depth of medium being 7 feet.

Bed "A."—Bed "A" is formed with a concrete floor 6 inches in thickness, having a fall of 9 inches from the centre to the circumference, around which an open concrete channel 12 inches wide is constructed.

A covered channel extending to the centre was built for experimental purposes, the walls of which at springing level are pierced with holes 4 inches in diameter, a pear-shaped depression being formed in the bed to drain to this channel.

The floor is chiefly covered with a layer about 12 inches in thickness of large slag for draining purposes, and for a small area with semicircular stoneware tiles, which, however, are not carried through the walls; the purifying medium consists of hard ball slag, broken and screened to the following sizes and depths:—3 feet of 2½-inch gauge; 1 foot of 1½-inch gauge; 1 foot of 1-inch gauge; 2 feet of ½-inch gauge.

The dry rubble wall supporting the medium is built of large pieces of slag, and is 3 feet thick at the base and 1 foot 6 inches at the top.

Shortly after the wall was built and before the medium was put in place, portions of it gave away, and on investigating the matter it was found that the slag contained a large number of fine cracks running in all directions; these cracks had opened out and caused the blocks to split.

The wall was strengthened by means of three wrought-iron bands, tightened with straining screws, and wedged with hard wood. Since this was done the wall has not given trouble, although one portion has moved slightly and on one occasion burst the rivets connecting the bands.

The sewage is distributed over the surface of the bed by means of an intermittent revolving distributor on the system of Messrs. Mather and Platt.

The height of the sewage in the supply tank at the commencement of the discharge is about 3·2 feet above the bottom of the trough forming the arm of the distributor.

The power is obtained principally from the turbine forming the centre of the apparatus, the greatest height of sewage in the trough being some 4½ inches, the power obtained from the reaction of the jets under this head being of very little assistance in turning the apparatus.

The sewage is applied intermittently in doses of about 1600 gallons every 9½ minutes, the rate of discharge on to the bed varying from 700 gallons per square yard per day to zero, and is spread over a period of 4½ minutes, the filling of the tank taking up the remainder of the 5 minutes.

Bed "B."—Bed "B" is constructed with a concrete floor formed with ridges at the circumference and at the diameter; the floor has a fall of 6 inches from the ridges to two covered concrete channels, 12 inches by 9 inches, carried across the bed, and dividing it into approximately equal areas. These discharge into an open brick channel formed round a portion of the circumference.

The floor is covered with an open or aërating floor of semicircular stoneware tiles carried through the walls.

On this floor is laid the purifying medium, consisting of screened gravel, obtained from excavations on the estate, containing a percentage of broken stones. The sizes and depths are:—3 feet of 2½-inch gauge, 2 feet of 1½-inch gauge, 1 foot 6 inches of 1-inch gauge, and 6 inches of ½ to ¼-inch gauge.

About one-half of the medium was washed before being put in place.

The medium is supported by means of a dry rubble wall, built of quartzite, from the Hartshill quarries at Nuneaton, the thickness at the base being 3 feet; the back is vertical, and the face has a batter of 5 to 1.

The haunches of the tiles are levelled up with concrete, and the base stones set in mortar. The wall is strengthened with concrete ties spaced about 8 feet apart horizontally along the centre line, and the top stones of the wall are set in mortar, to form a means of access round the bed.

The revolving distributor is of the Adams type, and has been somewhat modified and fitted with vanes to assist it in windy weather.

Bed "C."—The floor of bed "C" is formed similarly to that of bed "B," and is covered with an aërating floor of flat, blue brick tiles, which are carried through the walls of the bed.

The purifying medium consists of broken blue bricks, laid to the following sizes and depths:—3 feet of 2½ to 3-inch gauge, 1 foot 9 inches of 1½-inch gauge, 1 foot 6 inches of 1-inch gauge, and 9 inches of ½-inch gauge.

The sewage is applied to the bed by means of a mechanical distributor of the Scott-Moncrieff type, which consists of a Warren girder, having the lower boom in the form of a trough; one side of the trough is pierced with rectangular openings, fitted with sliding doors, through which the sewage flows into a smaller trough divided into bays, and fitted with adjustable, corrugated weir plates, the flow being equalised by means of baffle plates, which give an accurate distribution over the surface of the bed.

The centre of the apparatus consists of an ordinary packed gland-joint, and is supported on a horizontal ball-bearing.

The outer end of the girder is enlarged to form a house in which a 5½ H.P. Tangye oil engine is fixed. The engine makes about 280 revolutions per minute, and is geared so that the distributor revolves once in 7½ minutes.

The power is transmitted through a single driving wheel, and any surging motion is taken up by two idle wheels or rollers.

The weight on the driving wheel is about 13½ tons, and the apparatus requires 5 H.P. to start it, but 2 H.P. is sufficient to overcome the tractive resistance; it travels round a circular path formed of a heavy bridge rail riveted to an 8-inch steel joist.

This distribution was originally erected at Saltley, and was supported on brick piers fitted with cast-iron chairs, and the girder rail was designed for this purpose.

It was found that the girder and rail moved round on the chairs in a direction contrary to the direction of the machine and displaced the bedstones under the chairs and also several of the piers. It has therefore been erected on a continuous wall.

The wall is 5½ feet in height, and has a thickness varying from 3 bricks at the base to 1½ bricks at the top, and is built of brindle bricks set in hydraulic lime mortar. A continuous oak

PLATE NO. 2.

& REA DISTRICT DRAINAGE BOARD

DS AT MINWORTH GREAVES

"EXPERIMENTAL BEDS"

sleeper, 12 inches by 6 inches, is placed between the wall and the rail, and secured to the wall with long bolts, the rail being fastened down with coach screws; there is still a somewhat large amount of vibration, and it is proposed to fit the idle wheels with spring bearings in order to reduce this.

The oil engine will in the near future, when the electrical power scheme is completed, be replaced by a variable speed electro-motor.

Bed "D."—The concrete floor of bed "D" is constructed with a ridge across the diameter, having a fall of 9 inches each way for a width of 66 feet, and for the remainder of the outer segments, where the length rapidly decreases, a fall of 6 inches. An open brick channel is carried round the circumference.

The floor is covered with an aërating floor of semi-circular stoneware tiles carried through the walls.

One half of the bed is filled for the whole depth with a medium of washed Hartshill granite chippings, from ¾ inch to 1½ inch in size, and the other with Dosthill granite of the following sizes and depths:—5 feet of 2½ to 3½ inches, 1 foot 6 inches of 1½ inch, and 6 inches of ¾ inch.

This bed has been constructed with a system of aërating pipes laid in the medium.

The pipes are the ordinary land tiles in use on the farm, 3 inches in diameter, and are placed in three tiers at vertical distances of 1 foot 9 inches; and with the exception of the lines of pipes laid across the diameter, which open into a circular well surrounding the centre of the distributor, the pipes extend through from side to side of the bed.

On plan they form squares having sides of 15 feet, the junctions being formed of special pipes cut off to form a cross when laid.

The upper and lower tiers are laid at an angle of 45 degrees right and left to the centre tier. The wall supporting the medium is similar to that surrounding bed "B."

The sewage is distributed by means of a Candy Whittaker Buoyant Distributor.

The effluent chambers to these beds are formed with a floor sloping to a sump to retain any suspended matter in the effluent.

Washout pipes are fixed to each bed, in order to cleanse the arms of the distributors, these discharge into a washout drain 9 inches in diameter, to which are also connected the sumps in the effluent chambers and the supply pipes to the beds, so that the whole system of pipes, etc., can be periodically flushed; the drain is 450 yards in length and discharges on the farm lands.

Bed "E."—Bed "E" is of the rectangular type, and is 240 feet in length and 92 feet wide, and is constructed below the ground level.

The floor is of concrete, laid with a fall of 1 in 240, and is covered with an aërating floor of semicircular stoneware tiles, which are carried through the end walls. The effluent is collected in an open brick channel formed along the lower end of the bed.

The ends of the beds are excavated to the level of the floor and ramped back to give a free circulation of air.

The sides of the bed are excavated vertically and the medium filled in directly against the ground.

The medium is of screened ashes and clinkers, which form the waste from the city gas works, and of which some 60,000 to 80,000 cubic yards have been used for constructing the foundation of the farm roads.

The medium is laid to a depth of 6 feet, the lower 3 feet being of a large size (from 3 to 6 inches) and the remainder passed through a 1½-inch screen.

The sewage is distributed by means of a system of fixed sprays.

The bed is divided into four bays, each ⅛ acre in area.

The bays are independently supplied with sewage through two 8-inch diameter pipes spaced at 56 feet centres, connected to the 21-inch diameter main supply pipes and controlled by sluice valves fitted with indicators. The pipes are reduced to 6 inches in diameter halfway across the bed.

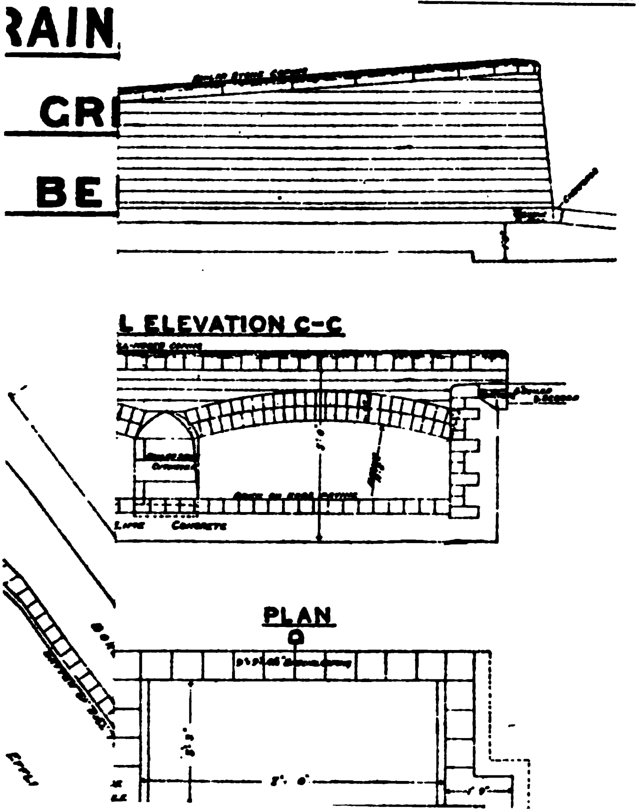
Junctions are fixed in the supply pipes, in which are fitted parallel lines of distributing pipes 3 inches in diameter, spaced at 9 feet centres.

The pipes are supported on the medium by means of cast-iron chairs 12 inches in diameter.

The distributing pipes are formed of light hot water pipes, having a thickness of about $\frac{3}{16}$ inch and cast with bosses spaced at 4-feet 6-inch centres in which are fitted the brass sprinkler jets. The pipes are jointed with a patent flexible joint made by Messrs. Jones and Attwood, of Stourbridge.

The supply pipes are carried across the bed and connected to the washout main before described.

PLATE NO. 3.



PERCOLATING BEDS.

The percolating beds now being constructed are four in number, each having an area of one acre.

They are of the rectangular type, and are 460 feet long, and 100 feet wide.

The floor is of concrete, laid with a fall of 9 inches across the bed, which is entirely covered with an aërating floor of semicircular stoneware tiles on which the medium is laid.

The medium of primary beds Nos. 7 and 8 is of broken blue bricks of the following sizes and depths: 2 feet 6 inches of 2½ to 3-inch gauge, 1 foot of 1½-inch gauge, 1 foot of 1-inch gauge, 6 inches of ½-inch gauge, the bricks after breaking screening out in these proportions.

The medium of primary bed No. 6 and the secondary bed will be formed with a layer 12 inches in thickness of 3-inch broken granite, covered with 4 feet of washed Hartshill granite chippings ⅜-inch to 1¼-inch gauge.

The beds are surrounded with walls of rubble granite built in a similar manner to those of the experimental beds, the thickness at the base being 2 feet 6 inches, and the face having a batter of 5 to 1.

The collecting channels extend the whole length of the longer side of the beds, and are built of brindle brickwork, and widened out to form gauging basins before joining the main effluent channels.

The walls of the channels are built in horizontal courses, coped with special coping blocks, over which the effluent flows; the inverts are of radiated bricks laid with a fall of 1 in 900, and finished against the side walls with a specially made brick to obviate cutting the bricks at the joint between the walls and invert.

The sewage is distributed by means of fixed sprinklers laid in the manner described in connection with experimental bed "E."

Humus Tank.—The humus tank constructed in the main effluent channel from the primary beds is of similar design to the silt tanks, except that it is the form of half a tank, a tumbling bay leading to the supply channel to the secondary beds taking the place of the other half. The emptying pipe is connected to the silt main, and discharges on to the farm lands.

The works with the exception of the 1½ acres of experimental beds, which have been constructed by direct labour under the Author's supervision, are being carried out by the following firms: constructional work, Mr. W. Cunliffe, Birmingham; cast-iron pipes, The Clay Cross Iron Co.; sluice valves, Messrs. Guest and Chrimes, Rotherham; special distributing pipes and flexible joints, Messrs. Jones and Attwood, Stourbridge; aërating floor, Mr. H. R. Mansfield, Church Gresley; medium (bricks), Messrs. Freakley and Co., Tipton; medium (granite), Jees Hartshill Granite Co., Atherstone.

COST OF 1 ACRE OF AN INSTALLATION OF 8 ACRES OF PRIMARY BEDS.

(Constructed by Contract.)

	£
Excavator, roads and paths	650
Concrete floor	783
Tile floor	800
Rubble walls	231
Channels	226
Proportion of main channels	154
	£2,844

Distribution.

	£
Supply and washout pipes	448
” ” on beds	258
Supply of distributor pipes	194
Sprinklers	50
	£950

Proportion of main supply pipes	£143
Medium, at 6*s.* 8*d.* a cubic yard	£2,500

Summary.

	£
Constructional	2,844
Supply and distribution	1,093
Medium	2,500
Total	£6,437

8 *Acres*, £51,496.

Cost of 1 Acre of an Installation of 4 Acres of Secondary Beds.

(Constructed by Contract.)

	£
Excavator, roads and paths	2,596
Concrete floor	774
Tile floor	800
Rubble wall	215
Channels	212
Proportion of main channels	154
	£4,751

Distribution.

	£
Proportion of main supply	210
Supply and washout	518
Pipes on beds	380
Distribution pipes	250
Sprinklers	50
	£1,408

Medium, at 6*s.* 3*d.* a cubic yard	£2,500

Summary.

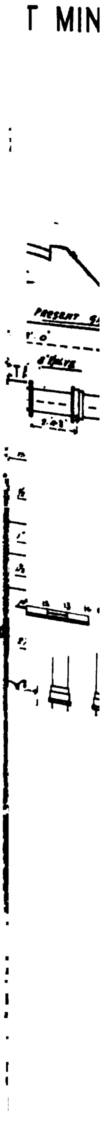
	£
Constructional	4,751
Distribution	1,408
Medium	2,500
Total	£8,659

4 *Acres*, £34,636.

Cost of Complete Installation of 12 Acres.

	£
Primary beds (8 acres)	51,496
Secondary beds (4 acres)	34,636
Silt tanks, pipes, etc.	8,217
Intake chamber	840
Humus tank	200
	95,389
Expenses of contracts	2,000
	97,389
18 acres of land at £130 per acre	2,340
	£99,729

Cost of complete installation per acre, £8,310.



Cost of Circular Bed "A" (7 feet deep).

(Constructed by Administration.)

	£
Excavator, roads and paths	95
Concrete	209
Tile floor	20
Rubble wall	137
Channels, manholes, etc.	52
Effluent pipes, etc.	6
Proportion of general labour and plant	40
	£559

	£
Proportion of main supply pipes	60
Supply pipes, etc.	25
Distributor, tank and fixing	330
	£415

Medium (slag) at 5*s.* 6*d.* a cubic yard	£950

Summary.	£
Constructional	559
Distribution	415
Medium	950
Total	£1,924

£1,924 *per quarter acre bed.*

Note.—The main effluent channel is existing and is not taken into acco

Cost of Circular Bed "B" (7 feet deep).

(Constructed by Administration.)

	£
Excavator, roads and paths	41
Concrete floor	173
Tile floor	164
Rubble wall	136
Channel, manhole, etc.	52
Effluent and washout pipes.	7
Proportion of general labour and plant	40
	£613

	£
Proportion of main supply pipes	60
Supply pipes, etc.	25
Distributor and fixing	157
	£242

Medium (gravel) at 4*s.* 6*d.* a cubic yard	£650

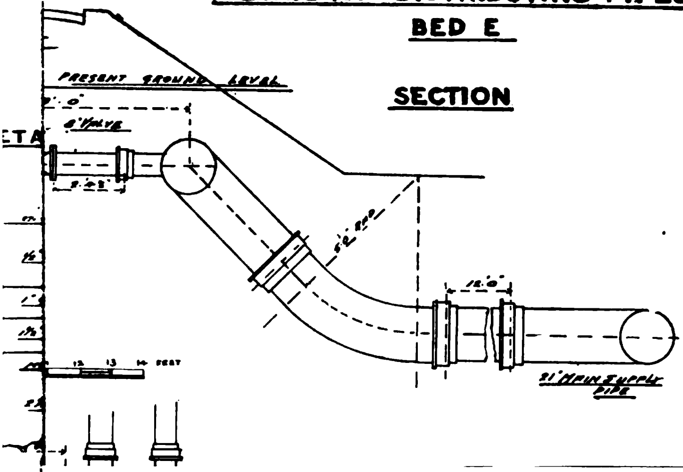
Summary.	£
Constructional	613
Distribution	242
Medium	650
Total	£1,505

£1,505 *per quarter acre bed.*

Note.—The main effluent channel is existing and is not taken into acco

DETAIL OF DISTRIBUTING PIPES
BED E

SECTION



COST OF CIRCULAR BED "C" (7 FEET DEEP).

(Constructed by Administration.)

	£
Excavator, roads and paths	61
Concrete floor	175
Tile floor	203
Wall (brick)	246
Channel, manholes, etc.	70
Effluent and washout pipes	7
Proportion of general labour and plant	40
	£802

	£
Proportion of main supply pipes	60
Supply pipes, etc.	26
Distributor and fixing, including rails, etc.	735
	£821

Medium (broken brick) at 6*s.* 3*d.* a cubic yard	£906

Summary.

	£
Constructional	802
Distribution	821
Medium	906
Total	£2,529

£2,529 *per quarter acre bed.*

Note.—The main effluent channel is existing and is not taken into account.

COST OF CIRCULAR BED "D" (7 FEET DEEP).

(Constructed by Administration.)

	£
Excavator, roads and paths	77
Concrete floor	183
Tile floor	166
Rubble wall	144
Channels, manholes, etc.	141
Effluent and washout pipes	6
Proportion of general labour and plant	40
	£757

	£
Proportion of main supply pipes	60
Supply pipes, etc.	24
Distributor and fixing (Candy type)	150
	£234

Aërating pipes in bed	£65
Medium (granite), one half at 7*s.* 6*d.* a cubic yard, one half at 6*s.* 6*d.* a cubic yard	£1,200

Summary.

	£
Constructional	822
Distribution	234
Medium	1,200
Total	£2,256

£2,256 *per quarter acre bed.*

Note.—The main effluent channel is existing and is not taken into account.

COST OF RECTANGULAR BED "E."

(*Constructed by Administration.*)

	£
Excavator, roads and paths	406
Concrete floor	314
Tile floor	320
Rubble wall	96
Channels, etc.	42
Effluent and washout pipes	6
Proportion of general labour and plant	80
	£1,264

	£
Supply and washout pipes including proportion of main supply pipes	200
Supply and washout pipes on beds	176
Distributing pipes	104
Sprinklers	30
	£510

Medium (clinker ashes) at 3*s.* a cubic yard	£726

Summary.	£
Constructional	1,264
Distribution	510
Medium	726
Total	£2,500

£2,500 per half acre bed.

OBSERVATIONS ON THE CONSTRUCTION AND WORKING OF THE BEDS.

The Use of Aërating Floors.—In many percolating beds recently constructed the bottom layer of medium has been composed of large material, the object being to allow the effluent to drain freely from the bed. In beds constructed on this principle the water, in finding its way to the channels, pursues a very erratic course through the intricate passages between the medium, and repeatedly changes its direction before it is clear of the bed. This must of necessity cause many small eddies and backwaters, in which the suspended matter, which has no great difficulty in finding its way by gravity to the bottom of the bed, is deposited in a gradually increasing quantity, which will in time render the lower portion of the bed useless for drainage purposes or for aëration, and the medium will, consequently, need to be taken out, cleaned and replaced.

The use of an open or aërating floor between the medium and the floor of the bed in a great measure minimises this defect.

The effluent, after percolating vertically through the bed, is at once entirely removed from contact with the medium, and finds a clear course open to the channels. The depth of water over the floor may be considerable, and still leave the necessary air space beneath the medium; thus the floor of the bed may be laid to a flatter gradient and head economised. The suspended matter is carried by the flow into the channels and there dealt with.

The Author has found, first, that the use of floors provided with circular holes is not satisfactory, as they become stopped up with portions of medium; and, second, that a flat floor has in some degree the defects of allowing the sediment to collect on the flat surface. It is also found at Saltley that the rough brick walls of the small channels forming the floor of the storm filter-beds have become coated with mucilage, similar to that found coating the medium of the bed.

To minimise these defects the Author designed the curved tile used for the beds, and he thinks that the smoothly glazed round surface will allow the sediment to easily reach the slots, which are carried right down to the foot of the tile. The long narrow slots cannot become entirely filled by the medium, and when the floor is carried through the walls of the bed the slimy coating and any heavy sediment can easily be flushed out, as the force of the flushing water is not destroyed by being allowed to spread out in all directions and become obstructed by the feet or supports of the floor. The distinct channels also induce a current of air, especially on windy days, and thus help in dispersing the heavier gases generated in the bed.

It is found after the beds have been resting for any length of time, that on re-starting them the first trickle of effluent from the beds provided with aërating floors reaches the channel in about 30 minutes, and from the floor covered with large slag in 45 minutes; also that the flow from the tiles is general in about 60 minutes, whilst after two hours about a quarter of the circumference of the channel draining the slag portion of the bed is still dry.

The effluent for some time is very turbid, and contains a large amount of suspended matter, the sediment in the effluent draining from the tile floor being two to three times greater than from an equal area of bed covered with slag. The sediment contained 26 per cent. of organic matter, chiefly broken down mucilage from the bed.

The beds were shut down during the August holidays, and the slag bed "A," after being allowed to drain for three days, was opened.

The medium was perfectly clear and had a pronounced earthy smell; when the large pieces of slag forming the floor were removed they were found to be embedded to a depth of from 1¼ inch to 1¾ inch in sediment, which appeared to be saturated with water. Several tiles were removed at the same time, and it was found that the floor was covered to a depth of ½ inch with a dry sediment.

Analyses of the two sediments gave the following results:

Sediment from part of bed under-drained with slag contained 11·69 per cent. of organic matter.

Sediment from part of bed with tile floor contained 4·96 per cent. of organic matter.

The sample from slag contained much broken down slag, and in each case the sediment was chiefly sandy matter of a dark colour.

Analyses of samples taken on June 4th from separate portions of the beds gave the following results:

Analyses of Effluent from Bed "A," June 4th, 1904.

	Dissolved Solids.	Free NH_3.	Albuminoid NH_3.	Chlorine.	Nitrates, etc., as Nitrogen.	Oxygen absorbed in 4 hours.
			Parts per 100,000.			
Bed under-drained with slag	132·5	1·661	·160	15·2	3·002	1·304
Bed under-drained with tiles	116·5	·153	·087	15·6	3·182	1·223

The amount of sediment from the beds appears to increase somewhat rapidly every 3 or 4 weeks, and an inspection of the diagrams shows that the oxygen absorbed increases at these times. This is no doubt due to the suspended matter making its way through the medium and collecting on the concrete floor until it is in sufficient quantity to be washed away; when the sediment makes its appearance, the channels and tiles are flushed out and cleaned with drain rods, after which the effluent is again clear.

The sediment contains a large amount of dust from the medium, which is gradually decreasing in quantity, and will probably disappear in course of time. The amount of sand from bed "B," which was partly filled with unwashed gravel, was very large, some 3 or 4 tons being taken out of the channels and sump during 2 weeks' working, and from an inspection of the outfall of the wash-out drain an amount of very fine sand and clayey matter equal to this appeared to have been carried away in the effluent.

The Use of Walls for Supporting the Medium.—If the bed is formed above ground level, the medium may either be supported by walls, or allowed to slope at its natural angle.

At first sight it may seem that the use of a wall is expensive, and many visitors to our works have expressed this opinion. It will be interesting, therefore, to compare the cost of the two methods.

Considering first the rectangular beds, the cost per acre of the rubble wall complete is 244*l.*, whilst if the medium is sloped the cost will be 500*l.* per acre.

In the case of circular beds the cost of rubble walls per acre in four quarter beds is 356*l.* per acre, and the cost of sloping the medium is 700*l.* per acre.

The price is calculated with medium at 6*s.* 3*d.* per cubic yard, placed in the bed.

Thus it is seen that the cost of the constructional work alone is about double if the medium is sloped, and, moreover, in the complete installation of 8 acres of beds at Minworth the area of land lost is 5800 superficial yards, or say, 1 acre bed complete.

Taking the land at 130*l.* per acre, the extra cost for 7 acres of beds will be 1,750*l.* plus 156*l.*—that is, 1,906*l.*, or 272*l.* per acre, and, in addition to this, a site for the lost acre of beds will have to be found elsewhere, which may increase the cost greatly, or it may be impossible to find a site at all.

COST OF SLOPING MEDIUM.

(Per acre of rectangular beds.)

	£	s.	d.
Excavation	41	8	2
Concrete	81	9	0
Tiles	91	6	6
Coping	19	12	0
Medium	247	16	3
	481	11	11
Pipes, etc.	19	0	0
	£500	11	11

COST OF RUBBLE WALL.

(Per acre of rectangular beds.)

	£	s.	d.
Wall	231	0	0
Excavation	1	15	6
Concrete	11	12	6
	£244	8	0

ANALYSES OF SEPTIC SEWAGE.

Parts per 100,000.

Date.	Estimated on Dissolved and Suspended Matters.			Chlorine.	Nitrates and Nitrites as Nitrogen.	Dissolved Solid Matter.	Suspended Matter.	
	Oxygen absorbed in 4 hours.	Free and Saline Ammonia.	Albuminoid Ammonia.				Total.	Loss on Ignition.
1903 Dec. 29	7·541	4·643	·368	11	·167	93		
1904 Jan. 5	7·534	4·297	·752	..	..	..	..	..
„ 12	9·738	4·207	·338	17·0	..	98·5	8·0	..
„ 19	9·502	4·009	·510	15·4	·229	73·5	29·5	..
„ 26	8·080	4·236	·472	16·6	·309	99		
Feb. 9	6·483	1·830	·217	15·8	·264	69·0	15·00	..
„ 23	10·494	3·512	·400	14·8	..	90·0	10·0	..
Mar. 1	10·798	3·720	·503	13·2	..	93·5	4·0	..
„ 9	7·636	4·338	·639	10·2	..	70·0	14·0	..
„ 24	9·574	4·318	·378	17·8	..	99·0	14·5	..
„ 30	8·600	3·188	·700	14·2	..	83·0	23·0	..
Apr. 26	12·366	5·175	·560	18·6	·284	85·5	28·5	..
May 5	12·194	4·929	·507	16·6	·477	107·0	11·5	..
„ 11	11·480	4·540	·772	11·2	·519	107·5	18·5	..
„ 19	18·314	4·647	·739	22·9	..	107·0	31·0	..
„ 27	13·506	4·453	·680	16·4	·188	91·0	30·5	..
June 2	11·250	3·450	·900	16·2	·213	97·5	29·5	..
„ 8	14·706	4·761	·567	24·4	·467	111·0	33·5	..
„ 9	26·363	4·725	1·875	28·2	..	85·0	112·0	..
„ 15	20·575	5·325	·850	20·0	·297	102·0	63·5	..
„ 16	13·701	4·107	·680	21·0	..	97·5	22·0	..
„ 22	13·650	4·875	·700	20·8	·679	111·5	24·5	12·0
„ 23	15·360	4·929	·583	20·6	..	113·5	24·5	..
„ 29	15·778	5·325	·791	22·2	·260	107·5	24·0	13·0
„ 30	13·833	5·175	·972	20·5	..	110·0	30·5	17·5
July 6	16·292	4·575	·733	21·2	·670	109·0	25·5	..
„ 7	16·405	5·175	·778	19·8	..	105·0	25·5	..
„ 13	14·056	4·671	·540	19·0	·618	102·0	20·0	11·0
„ 14	13·222	3·750	·708	20·4	..	104·0	27·0	10·0
„ 20	18·905	2·100	·814	21·2	·082	105·5	32·0	19·0
„ 21	20·830	4·680	1·020	20·4	..	99·0	60·0	30·5
„ 27	8·269	2·860	·284	21·0	·303	..	4·0	3·0

ANALYSES OF EFFLUENT.—BED "A."

Parts per 100,000.

Date.	Estimated on Dissolved and Suspended Matter.			Chlorine.	Nitrates and Nitrites as Nitrogen.	Dissolved Solid Matter.	Suspended Matter.	
	Oxygen Absorbed in 4 hours.	Free and Saline Ammonia.	Albuminoid Ammonia.				Total.	Loss on Ignition.
1903								
Dec. 29	1·205	·775	·113	13·2	2·960	117·0	Trace.	..
1904								
Jan. 5	1·572	1·500	·160	..	·310	..	..	..
„ 12	1·203	·863	·107	14·0	2·120	105·0	..	..
„ 19	1·155	·439	·108	12·8	1·912	94·5	..	..
„ 26	1·084	·451	·084	14·6	2·316	103·0	..	..
Feb. 9	2·088	·920	·221	10·0	1·451	169·5	..	..
„ 23	1·280	·389	·089	12·2	·252	103·0	..	..
Mar. 1	1·330	·966	·103	12·2	·160	105·5	..	..
„ 9	1·386	1·270	·177	11·0	..	95·5	5·5	..
„ 24	1·153	·412	·181	18·2	3·449	141·5	..	..
„ 30	·840	·345	·065	15·6	2·027	..	..	..
Apr. 26	1·283	·262	·106	16·4	2·438	107·5	5·0	..
May 3	1·071	·305	·229	15·6	3·275	83·0	9·0	..
„ 11	1·222	·906	·136	14·8	1·666	110·0	5·0	..
„ 27	1·494	·305	·118	15·6	·583	147·5	..	..
June 2	1·304	1·664	·160	15·2	3·002	132·5	..	..
„ 9	1·310	·284	·096	23·2	3·603	131·5	..	..
„ 15	1·588	·345	·127	18·8	2·735	112·5	4·5	..
„ 22	2·000	·820	·151	18·4	2·912	119·0	5·0	2·0
„ 29	2·778	·650	·151	18·4	2·921	118·5	6·0	2·0
July 6	1·348	·365	·101	18·8	1·795	114·0	3·5	..
„ 13	1·833	·148	·073	17·9	2·574	115·5	4·0	1·5
„ 20	1·791	·211	·125	19·2	2·574	115·0	7·5	3·5
„ 27	1·661	·183	·118	18·4	1·976	81·5	2·5	1·0

ANALYSES OF EFFLUENT.—BED "B."

Parts per 100,000.

Date.	Estimated on Dissolved and Suspended Matter.			Chlorine.	Nitrates and Nitrites as Nitrogen.	Dissolved Solid Matter.	Suspended Matter.	
	Oxygen absorbed in 4 hours.	Free and Saline Ammonia.	Albuminoid Ammonia.				Total.	Loss on Ignition.
1904								
May 3	1·225	5·268	·197	16·6	·284	90·5		..
„ 19	1·977	3·064	·159	20·2	·110	106·5		..
June 2	2·500	·201	·272	19·6	1·941	110·5		..
„ 8	3·984	1·401	·271	12·2	1·324	115·5	62·5	..
„ 22	3·050	·730	·136	18·4	3·005	115·5	7·5	3·5
„ 30	4·444	2·001	·329	21·5	3·281	113·5	18·5	6·0
July 6	6·040	·988	·302	20·0	2·857	112·0	21·5	..
„ 13	3·167	1·294	·238	19·7	1·020	115·0	11·0	4·0
„ 20	2·322	1·362	·151	20·0	2·763	108·0	6·0	5·5
„ 27	2·014	·454	·121	18·6	2·093	72·0	2·5	1·5

ANALYSES OF EFFLUENT.—BED "C."

Parts per 100,000.

Date.	Estimated on Dissolved and Suspended Matter.			Chlorine.	Nitrates and Nitrites as Nitrogen.	Dissolved Solid Matter.	Suspended Matter.	
	Oxygen absorbed in 4 hours.	Free and Saline Ammonia.	Albuminoid Ammonia.				Total.	Loss on Ignition.
1904								
Feb. 23	4·198	3·372	·246	..	1·203	..	..	..
Mar. 24	1·153	4·758	·319	18·5	1·327	116·0		..
Apr. 26	1·300	2·578	·154	17·4	·957	94·5		..
May 7	1·275	2·242	·196	14·9	1·216	79·0	..	..
„ 19	2·209	1·150	·145	21·6	2·537	110·5	..	..
„ 27	1·609	1·203	·158	13·0	2·100	168·0	..	..
June 2	2·500	·201	·272	19·6	1·941	110·5	..	..
„ 8	2·807	1·806	·266	15·4	1·779	126·0	..	..
„ 16	1·809	·710	·121	17·9	2·725	107·0	..	..
„ 23	2·496	·995	·152	18·2	..	115·0	6·5	..
„ 30	5·972	1·035	·358	20·4	3·397	106·5	30·0	9·5
July 6	3·708	·983	·302	20·0	2·851	112·0	21·5	..
„ 14	2·640	·361	·188	19·4	1·346	105·0	9·0	3·0
„ 20	2·285	·518	·118	18·9	2·808	105·5	4·0	3·5
„ 27	2·509	·290	·136	18·0	2·265	79·0	7·0	4·0

ANALYSES OF EFFLUENT.—BED "E."

Parts per 100,000.

Date.	Estimated on Dissolved and Suspended Matter.			Chlorine.	Nitrates and Nitrites as Nitrogen.	Dissolved Solid Matter.	Suspended Matter.	
	Oxygen absorbed in 4 hours.	Free and Saline Ammonia.	Albu-minoid Ammonia.				Total.	Loss on Ignition.
1904								
Apr. 26	2·766	4·917	·218	21·0	..	103·0	..	..
May 19	2·791	1·608	·200	20·0	2·350	123·0	..	..
June 2	1·957	·763	·208	19·4	2·702	112·0	..	..
" 8	3·556	·767	·145	21·9	3·000	121·0	25·5	..
" 15	2·961	1·578	·206	18·6	3·500	116·0	19·0	..
" 22	1·850	·730	·136	18·4	3·005	115·5	7·5	3·5
" 29	3·889	·863	·232	19·2	3·188	119·0	11·0	4·0
July 7	2·303	·763	·221	18·6	2·810	117·0	11·0	..
" 14	2·500	·945	·166	18·0	1·330	113·0	4·5	2·5
" 20	2·230	·744	·136	17·5	2·647	115·5	2·5	2·5
" 27	1·966	·407	·121	16·8	..	74·0	3·5	3·5

The analyses of the effluents show that a very high nitrification is obtained from the whole of the beds, and the Author believes this is largely due to the provision of an aërating floor, combined with the use of a fairly large (3-inch gauge) medium for the lower portion of the beds.

The smaller amount of suspended matter present in the effluent from bed "A" is also noticeable, and taken in conjunction with the results of opening the bed shows that a large amount of suspended matter is retained in the interstices of the slag forming the bottom of the bed.

The difficulty of estimating the relative efficiency of various beds and systems of sewage purification is well known, and the Author takes this opportunity of suggesting an equation, devised by Mr. O'Shaughnessey, the chemist to the Birmingham Drainage Board, which, whilst not taking note of all the factors, enables the results of working to be compared on a more equal basis.

The equation is as follows, and takes into account the elimination of the impurities in the sewage put on the bed in terms of the oxygen and albuminoid ammonia:

$$\frac{\begin{array}{c}\text{Impurities eliminated}\\ \text{measured by oxygen}\\ \text{absorbed test}\\ \text{(parts per 100,000)}\end{array} \times \begin{array}{c}\text{quantity treated on}\\ \text{unit area in lbs.}\end{array}}{100{,}000 \times \text{depth of bed}}$$

$$= \begin{array}{c}\text{work done by bed per unit foot}\\ \text{(measured by the oxygen}\\ \text{required to eliminate}\\ \text{the impurities).}\end{array}$$

An example may be taken to illustrate the method:

BED "A." MAY 11, 1904.

Oxygen Absorbed.	
Sewage.	Effluent.
11·480	·772

$$\frac{10{\cdot}608 \times 810{,}000 \text{ gallons per day per acre} \times 10 \text{ lb.}}{100{,}000 \times 7 \text{ feet}}$$

$$= 118{\cdot}66 \text{ lb. oxygen.}$$

That is—Impurities have been eliminated equivalent to the use of 118·66 lb. of oxygen per acre foot of bed.

The percentage of purification and the work done by the beds have been calculated and are given in graphic form, and it will be noticed in connection with bed "A," that although the percentages of purification on 5th January and the 27th July were the same (79·9), the work done by the bed was on the latter date double that on 5th January, the work measured in lbs. of oxygen being on January 5th 38·71, and on July 27th 76·65.

Also on March 30th the equivalent in lbs. of oxygen was 75·89, with a percentage of purification of 90·2, and on July 20th 187·74, with a percentage of purification of 90·5.

The Author thinks that a comparison of various processes on these lines would be of great interest, and regrets that time would not allow of a comparative table being prepared.

A table showing the results of the working of beds "A," TABLE SHOWING PERCENTAGE OF PURIFICATION AND EQUIVALENT WORK DONE PER ACRE FOOT OF BED. Parts per 100,000.

Date.	Oxygen Absorbed.		Albuminoid Ammonia.		Percentage of Purification.		Equivalent Work done per acre-foot of Bed.		Remarks.
	Sewage as put on Bed.	Effluent.	Sewage.	Effluent.	Oxygen	Albuminoid Ammonia.	Oxygen.	Albuminoid Ammonia.	
BIRMINGHAM SEWAGE WORKS.									
1904. *Bed A.*									
Jan. ..	7·463	1·238	·518	·115	80·0	77·0	46·6	3·09	Single percolation bed. Area, ¼ acre. Depth, 7 feet.
March	9·152	1·177	·555	·131	86·9	73·6	83·0	4·16	
May ..	12·393	1·262	·653	·161	89·8	73·2	116·4	5·76	
June ..	17·511	1·796	1·023	·137	88·7	84·3	163·5	9·47	
July ..	14·380	1·658	·593	·104	87·2	78·9	119·3	5·21	
1904. *Bed C.*									
May ..	14·67	1·697	·642	·166	88·5	72·8	118·2	4·34	Ditto.
June ..	16·10	2·855	1·002	·208	81·2	79·8	148·4	13·30	
July ..	14·681	2·785	·697	·186	78·9	68·8	164·6	6·68	
1904. *Bed E.*									
June ..	15·179	2·842	·761	·185	81·1	75·6	213·5	9·86	Ditto.
July ..	14·17	2·249	·646	·161	82·8	72·2	171·2	7·06	
MANCHESTER SEWAGE WORKS.									
1903.									
Apr. 22	8·10	2·31	..	..	71·5	..	51·38	..	Single contact bed. Area, ½ acre. Depth, 3·33 feet.
May 20	7·37	2·40	..	..	67·4	..	52·11	..	
June 17	8·46	3·11	..	..	63·2	..	58·69	..	
July 15	8·44	2·78	..	..	67·0	..	52·05	..	
Aug. 12	7·40	3·34	..	..	54·8	..	43·23	..	
Sept. 9	6·30	1·84	..	..	70·8	..	60·44	..	
Oct. 7	8·00	2·54	..	..	68·2	..	73·11	..	
Nov. 4	6·10	1·87	..	..	69·3	..	70·96	..	
Dec. 2	8·32	2·59	..	..	68·8	..	75·80	..	
Dec. 30	9·83	3·19	..	..	67·5	..	77·10	..	
1904.									
Jan. 27	9·91	3·29	..	..	66·8	..	91·80	..	
Feb. 24	8·29	2·84	..	..	65·7	..	84·40	..	
Mar. 30	10·09	3·31	..	..	66·2	..	88·75	..	

"C," and "E," and the contact beds at the Manchester Sewage Works is given.

In conclusion, the Author begs to express his thanks to the engineer, Mr. J. D. Watson, for placing at his disposal the data included in the paper, and to Mr. O'Shaughnessey, the chemist to the board, for allowing him to publish the equation.

The data in connection with the Manchester beds are taken from the report of the Royal Commission on Sewage Disposal.

DESCRIPTION OF REFUSE DESTRUCTOR AND ELECTRICAL POWER GENERATING STATION IN COURSE OF ERECTION AT SALTLEY.

BY D. J. ROBERTS.

THIS combined scheme has for its object the cremation of all kinds of ordinary house and shop refuse, and the utilisation of the otherwise waste heat from the refuse furnaces for the purpose of raising steam for generating electricity for traction and lighting purposes.

The important developments of electricity for traction and lighting purposes and the destruction of refuse by cremation present a new problem in building.

In connection with building for the housing of mechanical installations, etc., planning may be justly termed scientific.

Comparing ancient with modern construction the former could hardly be termed a science.

We have now arrived at a period of our history when the engineer and architect have at their command all kinds of constructional materials, tested in various ways, and scientifically investigated.

An almost perfect system of construction has thereby been based on scientific principles, and reliable facts have been acquired by experimental tests which have undoubtedly placed construction on a scientific basis.

The days of few types, both in mechanical installations and buildings, have gone by, and to meet present day requirements of machinery, etc., we are confronted with a class of building which derives its form chiefly from the fittings and equipment, and in connection with which a fair knowledge of machinery is of great value. Originally, it may be said that it was con-

sidered sufficient to provide buildings
for the protection of machinery, but no
sive and valuable plant is laid down, it
be housed in substantial brick or stor
tectural character. Externally, buildi
often looked at and considered as ere
concealing operations or industries tl
their walls, rather than as external w

In dealing with the external elev
was the Author's desire to gain effe
naturally grew out of the general
introduction of colour produced by tl
Owing to the rapid growth of our l
sites for buildings of this class has
Few designers are now sufficiently f
what they would term an ideal site
opinion that the site of these buildin
may be truly termed ideal, with a
and two approach roads communic
boundaries. It is also convenientl
ing area.

In connection with the destru
of the above roads as an entranc
and from the inclined roadway.

The existing general level of
nance Datum which it is intende
304·00 above Ordnance Datum,
bank and the main approach roa

The longest way of the site
east, the Birmingham and Warw
north-west side and the Drainag
south-east side, and facing this
foremen's cottages in connect
containing parlour, kitchen, sc
the ground floor, and three bed
the first floor.

Owing to the scheme being
arrange the buildings on the
destructor house, chimney an
the furnaces should be erected
town of Birmingham (which ha

---

equal dimensions, the height from fl

the right of the inclined roadway w
passage to the clinkering area, a wor
staircase from the clinkering floor up
workshop and store room will be heat
the low-pressure system, the heatin
cast-iron pipes suspended from th
the line of piping will be a stea
and at the other end next th
1-inch reducing valve to reduce th
per square inch, and also a sto
shutting off the system when n

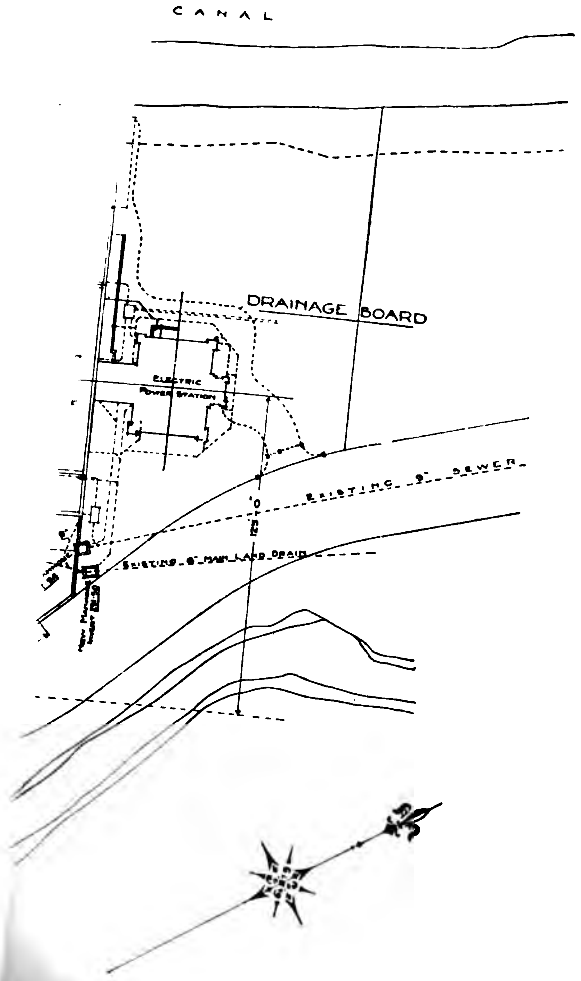
inclined roadway will be a pum
at present two boiler-feed pum
working the rams of the feed doo
reserved for a small electr
to be put in at a later dat
feet 2 inches by 18 feet 6 inche
immediately opposite the inclin
light has been overcome
arches of the inclined roadw
the building, to allow of t
either side of the room und
pumps will be "Mumford'
steam cylinders and 4-in
6-inch stroke, each capable
against a pressure of 160
pump will be "Heena
a pressure of 10 cwt.
to an entirely enclosed ste

dway this section will cont
ering area, two water-clos
lavatory basin, and a m
to these rooms will be [illegible]

station on land belonging to

ged to commence adjoining
e and will run in a north-
e destructor house in the
ng the roadway.

NECHELLS—PLATE I.



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sidered sufficient to provide buildings of a very primitive kind for the protection of machinery, but now, in cases where extensive and valuable plant is laid down, it is felt that they should be housed in substantial brick or stone buildings of an architectural character. Externally, buildings of this class are too often looked at and considered as erections for the purpose of concealing operations or industries that are carried on within their walls, rather than as external witnesses of these activities.

In dealing with the external elevation of these buildings, it was the Author's desire to gain effect by those features which naturally grew out of the general construction and by the introduction of colour produced by the materials to be employed. Owing to the rapid growth of our large towns, the question of sites for buildings of this class has become an important item. Few designers are now sufficiently fortunate to have to deal with what they would term an ideal site; however, the Author is of opinion that the site of these buildings, especially for a destructor, may be truly termed ideal, with a canal forming one boundary and two approach roads communicating with two of the other boundaries. It is also conveniently situated within the collecting area.

In connection with the destructor, it is intended to use one of the above roads as an entrance and the other as an exit to and from the inclined roadway.

The existing general level of the site is 298·00 above Ordnance Datum which it is intended to raise to a finished level of 304·00 above Ordnance Datum, this being the level of the canal bank and the main approach road to the Drainage Board's farm.

The longest way of the site runs from south-west to north-east, the Birmingham and Warwick Junction Canal being on the north-west side and the Drainage Board's approach road on the south-east side, and facing this road it is intended to erect two foremen's cottages in connection with the destructor, each containing parlour, kitchen, scullery, pantry, coals and w.c. on the ground floor, and three bedrooms and two linen-closets on the first floor.

Owing to the scheme being a joint one, it was necessary to arrange the buildings on the site in such a manner that the destructor house, chimney and everything in connection with the furnaces should be erected on land belonging to the Corporation of Birmingham (which had an area of about 2 acres) and the boiler-house and electric power station on land belonging to the Drainage Board.

The inclined roadway is arranged to commence adjoining the south-west boundary of the site, and will run in a north-easterly direction and join up to the destructor house in the centre of the front of this building facing the roadway.

Next to the destructor house comes the boiler-house and then the electric power station, all adjoining. The entrance to the inclined roadway will be from the Drainage Board's private approach road, and adjoining this will be a weigh-office measuring 14 feet by 12 feet with a weigh-bridge having a table 12 feet by 8 feet and capable of weighing up to 10 tons. In plan, the inclined roadway resembles the letter T, this form of plan being due to the site not being of sufficient length to introduce a straight roadway with a sufficiently easy gradient.

The cross portion at the lower end will be 150 feet long and 32 feet wide between the parapet walls and will form an entrance at the one end and an exit at the other, to and from the tipping floor. There will be one track only on this portion which will be 28 feet wide laid on hard dry filling supported by retaining walls, and inclined at a gradient of 1 in 18. The remaining portion of the roadway up to the tipping floor will be carried on semicircular arches, 14 feet span, each consisting of three half-brick rings in cement, the haunches being filled in with lime concrete. The total length of this will be 242 feet and 20 feet 2 inches wide between the parapet walls and the gradient 1 in 19. There will be two tracks on this section, each 6 feet 4 inches wide between the kerb; this width of track will be sufficient to allow of motor vehicles being used should the Health Committee at some future time decide to adopt the use of this form of vehicle.

The whole of the roadway will be paved and kerbed with Mountsorrel granite—the kerbing being 10 inches by 5 inches, running stones 12 inches by 6 inches, and the paving 9-inch by 4-inch by 4-inch setts—and finished on each side with parapet walls 4 feet high coped with stone.

Leaving the inclined roadway we come to the destructor house. This building will be two stories in height, measuring internally 104 feet long and 43 feet wide.

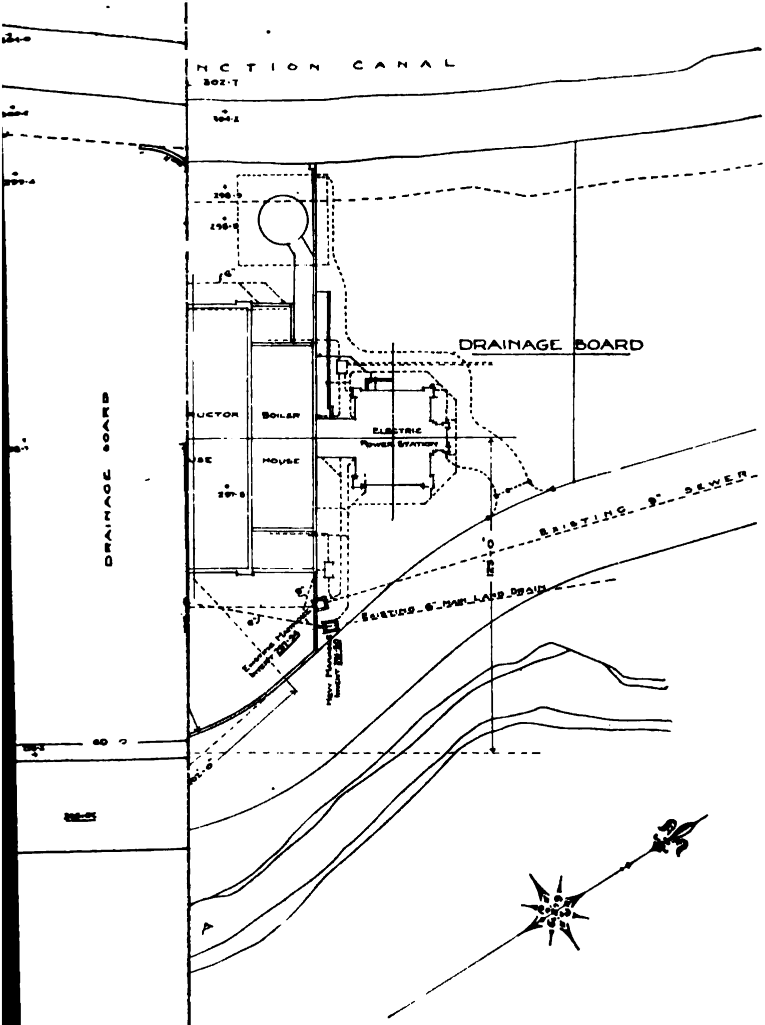
The ground floor will be divided longitudinally into three sections, of practically equal dimensions, the height from flo to ceiling being 15 feet.

The first section on the right of the inclined roadway wi contain a side entrance passage to the clinkering area, a work shop, store room, and a staircase from the clinkering floor up t the tipping floor. The workshop and store room will be heat by means of steam on the low-pressure system, the heatin pipes being 3-inch diameter cast-iron pipes suspended from th ceilings. At the one end of the line of piping will be a stea trap to run off condensation, and at the other end next th main steam pipe will be a 1-inch reducing valve to reduce th pressure from 160 lb. to 10 lb. per square inch, and also a sto valve for the purpose of shutting off the system when n required.

Immediately opposite the inclined roadway will be a pum room, in which will be placed at present two boiler-feed pum and one hydraulic pump, for working the rams of the feed doo to the cells, and space will be reserved for a small electr lighting set, which is intended to be put in at a later dat The size of this room will be 20 feet 2 inches by 18 feet 6 inche Owing to this room being immediately opposite the inclin roadway, the difficulty of securing light has been overcome b placing the end abutment to the arches of the inclined roadwa about 6 feet from the front of the building, to allow of tw large windows being fixed one on either side of the room und the roadway. The two boiler-feed pumps will be "Mumford's vertical pumps, with 6-inch diameter steam cylinders and 4-in diameter water cylinders with 6-inch stroke, each capable delivering 2400 gallons per hour, against a pressure of 160 l per square inch. The hydraulic pump will be "Heenan Three-Throw," capable of maintaining a pressure of 10 cwt. the square inch, directly coupled to an entirely enclosed stea engine of about 12 B.H.P.

On the left of the inclined roadway this section will conta a second side entrance to the clinkering area, two water-close two bath-rooms, each containing a lavatory basin, and a me room for the workmen. The access to these rooms will be fr a passage 4 feet wide running parallel with the front of t building, and communicating with the side entrance to t clinkering area above referred to. The object of arranging th rooms to open out of a passage is to minimise as far as possi

OF SITE (R STATION, NECHELLS—PLATE I.



—Existing Lev5·00.

150 180ft.

To face p. 64.

the probability of dust finding its way into them from the clinkering area. The hot water to the baths and lavatory basins will be supplied from a Royle's patent calorifier fixed in the mess-room, and heated by steam conveyed from the low-pressure side of the supply to the heating pipes in the pump room.

Over the calorifier will be fixed a galvanised wrought-iron tank of 80 gallons capacity connected to the calorifier with a 2-inch flow and return. In addition to the small open range in the mess-room there will be a Royle's patent steam kettle to hold 10 gallons and a steam-cooking oven.

The second or middle section will simply be a wide corridor, 16 feet wide, extending from one end of the building to the other, which will be used as a clinkering area. At each end of this area there will be large openings in the gable ends (fitted with doors) so as to secure good cross ventilation, and through which the clinkering trucks will be run out into the open on rails laid in the floor of the clinkering area.

The third section will be occupied by the "cells" and the "air heaters," the latter being placed in the centre, and four cells arranged on either side facing the clinkering area with the settling chambers arranged at the end of each set of cells furthermost from the "heaters."

The floor of the clinkering area, store room and workshop, will be paved with a hard brick on edge in cement. The floors of the pump-room, mess-room, bath-rooms and w.c.'s, will be paved with 6-inch square tiles. The walls of the pump-room and clinkering area will be finished up to 5 feet above floor with brown glazed bricks.

The internal walls generally will be flat-pointed and colour washed.

The cells to be erected are those known as the "Heenan Patent Top Feed," the makers being Messrs. Heenan and Froude, Manchester. Each cell will have a grate area of 25 square feet.

There will be eight of these cells arranged in two distinct sets, each set consisting of four cells, one air heater and fan, and one settling chamber 24 feet by 4 feet by 10 feet, connected to one boiler and forming one unit of plant.

The cells and settling chambers internally will be entirely lined with 9 inches of fire brickwork, and externally with common hard brickwork 14 inches thick, and between this outer and inner lining of brickwork there will be a 1½-inch cavity filled up with wired silicate of cotton. The whole of the brickwork to the cells and the settling chamber, will be braced together by means of 6-inch by 2½-inch double channels placed vertically at intervals of about 6 feet 9 inches; these will in turn be secured to horizontal 10-inch by 3-inch channels let in flush with the brickwork, and fixed in such a position as to take the thrust of the arched covers of the cells. The vertical double channels will be of sufficient length to extend about 9 inches above the brickwork for the purpose of receiving the ends of the 1¼-inch diameter tie rods, which are to bind together one side with the other.

The fronts of the cells will be of very heavy construction, each weighing something like 45 cwt. Each front will be fitted with regulating valves to adjust the admission of heated air from the heaters both above and below the grates. The hot air will be conveyed from the heaters to the cells below floor, in brick ducts 30 inches wide and 24 inches deep, running under the entire length of each set of cells, immediately under the fire grates. The clinkering doors will be lined internally with firebrick, and arranged to slide upwards and balance by means of balance weights. Such portions of the fronts to the cells that are not covered by ironwork will be finished with glazed brickwork, so that they can be easily kept clean. There will be two refuse hoppers, one over each set of cells, each measuring 32 feet long, 13 feet wide and 6 feet deep, below the tipping beam. The floors of these hoppers will be constructed of rolled steel joists and concrete, floated smooth and so placed that no portion of the same shall be in contact with the upper part of the cells, so as to avoid as far as possible the heating of refuse that may be stored in the hoppers previous to charging.

The feed-doors to the cells will be made to slide and rendered fireproof by means of curved firebrick tiles. Each door will be provided with a water-trough to ensure an inch water seal, to prevent the blowing out of sulphurous fumes when the doors are closed. These doors will be worked by means of small hydraulic rams, each working at a pressure of 500 lb. per square inch, and operated by levers from the tipping floor. Each ram will be connected up to the three-throw hydraulic pump in the pump-room.

The air heaters will each provide about 1500 square feet of heating surface. They will consist of 3-inch diameter boiler tubes fixed in a vertical position, and secured at their upper and lower extremities to horizontal plates, and entirely surrounded with brickwork braced together in a similar manner to the cells. The hot gases, after leaving the boilers, will be made to pass through these tubes on their way to the economiser and chimney, thereby heating the forced air which will be made to circulate around the outer surface of the tubes on its way from the fans to the cells. It is claimed by the makers that the introduction of hot forced air into the cells gives an initial temperature of from 300 to 350 degrees. In addition to this, heated air has a greater avidity for absorbing moisture, consequently with the use of hot air the usual drying hearth in the cell is dispensed with. Then again, with the use of forced air it is easier to regulate the supply of air to the cells to that of the theoretical supply required. With the aid of forced heated air it has been contended for years by those who have closely studied the matter that it is possible to so regulate the forced heated air and the pull of the chimney that a perfect balance of gases can be secured. With this condition existent in the cells cold air cannot enter even with the doors wide open. The fans for forcing the air to the cells will be placed on the tipping floor, immediately over the heaters, and in close proximity to the hoppers. It is hoped that, by placing the fans on this floor, they will greatly assist the circulation and the removal of foul air in this part of the buildings. The fans will be connected down to the heaters by means of square steel tubes. Each fan will be 66 inches diameter, in order that they may be run at a comparatively low speed, and so that differences in volume can be obtained without much fluctuation in wind speed. The fans will be coupled up to and driven by entirely enclosed self-oiling Belliss engines of 12 B.H.P. each. These fans will be of sufficient capacity to enable 60 tons of ordinary house and shop refuse to be burned in twenty-four hours on one set of four cells, which is equal to 56 lb. per square foot of grate per hour. The makers guarantee that, when eight cells and two boilers are in use under ordinary conditions, the plant will evaporate not less than 9000 lb. of water when the furnaces are fed at the rate of 8000 lb. of refuse per hour.

The first floor of the destructor house will contain the refuse-hoppers, the air-fans and engines, the tipping area, and a staircase down to the clinkering area.

The tipping area will measure 104 feet long and 27 feet wide, and in addition to this, between the two hoppers there will be an enclosed area 26 feet long and 16 feet wide where it is intended to place the fan and engines. The total width of this floor from wall to wall will be 43 feet, and the height up to the tie rods of the principals will be 14 feet in the centre. The floor will be constructed of concrete and rolled steel joists, the main joists being 14 inches by 6 inches and the longitudinal joists 7 inches by 4 inches, fixed at 3 feet centres and riveted to the main joists. Immediately under the tipping beam there will be two longitudinal joists placed side by side. The main joists where they come opposite the hoppers will be carried by the double vertical channels intended for bracing the furnace front. The cement concrete filling to the floor will be 10 inches thick at the springing and 6 inches thick at the crown, supported on cambered iron centring fitted between the longitudinal joists and finished with 4-inch Mountsorrel cubes, except the area provided for the fans, which will be finished with concrete flags.

The tipping beam will be of pitch pine, 16 inches by 12 inches, so fixed that at least 12 inches will stand up above the finished paving and continued from one end of the building to the other, secured in position by means of 1-inch diameter bolts of sufficient length to pass down between the double row of longitudinal joists above referred to. In addition to these bolts the beam will be further secured by steel brackets riveted to the ends of the main joists opposite the hoppers. Between each hopper and the ends of the building there will be well-holes, each 14 feet by 4 feet, communicating with the clinkering floor below, for the purpose of securing an exit for the heat and smoke that may accumulate under this floor during clinkering operations. The roof over this floor will be carried on steel principals placed at 8 feet centres, and will contain a large louvre ventilator along the entire length of the building. The internal walls will be flat, pointed, and colour-washed.

Leaving the destructor house, we next come to the boiler-house. This building measures internally 73 feet 6 inches long and 24 feet 6 inches wide, and is 13 feet high from the top of the flues to tie rod. Accommodation is here provided for three boilers, one economiser (with provision for adding another 64 tubes) and the necessary flues. The flues inside the house are to be of large dimensions so as to secure easy access for cleaning purposes. In the centre of the building will be the main flue running across at a low level from the heater in the destructor house to the economiser. On one side of this flue will be placed two boilers side by side, and on the opposite side will be placed one boiler and the economiser with a by-pass flue between. Openings covered with portable fire-brick slabs in chases will be provided between the lower boiler flues and the above main low level flue from the heater for the purpose of sweeping the soot or dust from the boiler flues into the main flue and thence to a point in this flue under the destructor house floor where it can be hoisted up by means of a small permanent winch and deposited into the clinkering trucks close at hand.

The three boilers, which are to be supplied by Messrs. Taylor and Sons, of Marsden, Yorkshire, will be of the type known as Lancashire boilers, each measuring internally 30 feet long and 8 feet diameter, constructed for a working pressure of 160 lb. per square inch. Two of these boilers will be gas fired, that is, they will be connected with the furnaces, while the other will be adapted for coal firing, and will be a stand-by. The gas-fired boilers will be connected to the settling chambers by means of steel rings lined internally with fire-bricks. Each boiler will be fitted with one Hopkinson's patent "Duad" safety valve for high steam and low water, one Hopkinson's patent "Duplex" safety valve for high steam only, one Hopkinson's patent parallel side blow-off valve, and one Hopkinson's isolation valve.

The pressure and water-gauges on the gas-fired boilers will be fixed on the sides on Hopkinson's columns (C type) with guards near the back ends of the boilers facing the destructor house so that they can be seen from the clinkering area. The gauges on the coal-fired boiler will be placed in the usual position on the firing end, together with the feed inlet valve. The feed inlets to the gas-fired boilers will be at the top near the back ends. The valves in these cases will be Hopkinson's patent "Accessible Feed Valves" worked from the clinkering area by means of rods and hand-wheels, the hand-wheel being arranged to be worked adjoining the pressure and water gauges. From this position it will also be arranged to work the flue dampers in connection with the gas-fired boilers.

It is intended to set the boilers on Pearson's patent seating blocks with asbestos cushion, and to cover them with Pearson's patent fire-brick covering blocks laid on a layer of asbestos. The emptying pipes from the boilers will discharge outside the building into catch-pit chambers, constructed for the purpose of arresting any deposit from the boilers which would otherwise be discharged into the drains.

The economiser will be supplied by the Clay Cross Company, Chesterfield, and will consist of 128 tubes 9 feet long, $4\frac{9}{16}$ in. diameter, fixed vertically and forced into longitudinal top and bottom boxes in sections forming metal-to-metal joint.

The tubes will be arranged in two groups of 64 each, and connected together with cast-iron expansion elbows. Each tube will be fitted with triple scrapers, worked by a small 2-H.P. 220-volt three-phase motor.

At the south-east end of the boiler-house will be a stokehole in connection with the coal-fired boiler, and at the opposite end there will be a cast-iron storage water tank at a high level to hold 5000 gallons, which will be supplied from the city main.

The furnace chimney, which will stand on a cement concrete base 36 feet square and 8 feet thick, will be at the end of the boiler-house next the canal. A portion of the main flue from the boiler house to the chimney for a distance of 28 feet, will be increased from 3 feet 6 inches by 7 feet 3 inches to 6 feet by 7 feet 3 inches, so as to decrease the velocity, thereby facilitating the settlement of any dust before reaching the chimney.

The total height of the chimney above the intended finished ground level will be 165 feet, and the internal diameter at the top will be 7 feet. Above the foundations, the chimney for its entire height will be circular in plan, and the batter on the outside face will be 1 in 40—the bond being three rows of stretchers to one row of headers. The top will be finished with a strong cast-iron casing, bolted together in sections, and filled in on the inner side with brickwork; below this there will be a terra-cotta cornice, and some buff plain brick bands, which should form a pleasing contrast to the brindle bricks which it is intended to use for the facing generally. Internally, there will be a firebrick lining 130 feet high, 9 inches thick for the first 75 feet of its height and 4½ inches thick for the remaining 55 feet. At the top, this lining will be finished with a keyed firebrick coping, laid loose on the top of the lining to protect the cavity between the lining and the main wall of chimney.

The conductor tape will be 1¼ inch by 1⅛ inch, copper connected at the bottom end to a 3 feet square copper earth-plate No. 16 B.W.G., and finished at the top with a solid ¾-inch diameter copper air terminal, with four ½-inch diameter inclined points. The terminal will be fixed to a wrought-iron bracket bolted to the cast-iron casing before referred to.

Having described the boiler-house and appurtenances, we now come to the power station. The front portion of this block of buildings will be taken up entirely by the engine-room on the ground floor, with a basement under of similar area.

Between the engine room and the boiler-house will be a small wing, containing on the ground floor a store room and lavatory, with a basement under, and on the first floor a small mess-room for the attendant containing a window overlooking the engine room. The engine room will be 36 feet long, 28 feet 6 inches wide, and 22 feet high from the floor to the tie-rod. The main front will face north-east, and in the centre of this front will be a small entrance-porch or vestibule, to serve as the main entrance to this portion of the scheme, approached from the Board's private road. There will be no communication internally between the power station and the boiler-house; the arrangement between the Drainage Board and the Health Committee being that the production of steam shall be entirely governed by the Health Committee, for which the Drainage Board will pay an annual fixed sum.

The generating plant in the engine room will consist of two 3-phase generators, direct driven by Belliss engines, and provision will be made for a third set.

The engines will be compound two-crank engines, each capable of developing 175 B.H.P. at a steam pressure of 130 lb. per square inch, and the generators will be B.T.H. standard 115 k.w.—2000 volts—50 cycles—revolving field three-phase generators, each equipped with shaft, half coupling, outboard bearing, and direct-coupled exciters. Each of these will be capable of standing an overload of 10 per cent. continuously, 25 per cent. for one hour, and 50 per cent. momentarily. The engine room will also contain the switch-board. This will consist of four panels of polished marble. Two of these panels will control the generators, and the remaining two panels will be for the high tension and low tension feeders. The panels for the generators and the high tension panel will each be

90 inches high and 24 inches wide, built up in two sections; the low tension panel will be 90 inches high and 16 inches wide. The whole of the electrical work will be carried out by the British Thomson-Houston Company, Rugby.

A small lighting set will also be placed in the engine room for the purpose of lighting the power station and the precipitation tanks at Saltley.

This will consist of a single vertical engine by Messrs. Bryan, Donkin and Clinch, capable of developing 15½ B.H.P. at a speed of 550 revolutions per minute when supplied with steam at 100 lb. pressure, connected direct to one 10-k.w. 220-volt compound-wound generator, with one field rheostat and multi-contact switch.

The exhaust steam from the engines will be taken down into the basement, and thence to a feed-water heater to be fixed outside, between the engine room and the boiler-house. The class of heater it is intended to adopt will be Webster's vacuum feed-water heater and purifier, with oil separator attached capable of raising the temperature of about 8000 lb. of feed-water per hour from 50° F. to about 206° F. and over, when fed continuously with exhaust steam, at the rate of not less than 1400 lb. per hour.

The travelling crane in the engine room will be supplied by Messrs. Higginbottom and Mannock, Manchester. This crane will be capable of safely lifting 6 tons with all motions worked by hand-chains from below. In construction it will consist of two 14-inch by 6-inch cross steel girders, supporting the necessary travelling and lifting gearing, resting at each end on steel carriages, made up of plates and angles, each carriage being fitted with two cast-iron travelling wheels, 21 inches diameter.

The arches for carrying the gantry beams (usually placed internally) have here been placed outside, in which case the beams and rails will rest on the main walls, which will be carried above the gantry beam by the external arches. This form of construction will greatly add to the appearance of the building, and will dispense with a number of objectionable angles in the engine room.

The engine room will be ventilated by means of a 16-inch diameter electric fan, with motor for 220 volt single phase, capable of circulating 1260 cubic feet of air per minute.

There will be a glazed brick dado in the engine room and porch, 6 feet high, and above this the walls will be plastered and colour-washed. The floors will be tiled with encaustic tiles.

The following is a brief description of the general materials to be used:—

The brickwork generally will be executed in Staffordshire brindle bricks, faced externally with selected similar bricks having plum-coloured stretchers and blue headers, laid old English bond to a gauge of seven courses to two feet. Buff, plain and moulded bricks will be sparingly used externally, so as to introduce a little colour in the elevations. The window-sills, wall copings, and the copings to the gable ends will be of Horsley Castle stone.

The roof trusses will be framed of mild steel with tee rafters, fish-bellied struts and round bar tie-rods. The tensile strain specified for all steel work is 27 to 31 tons per square inch and elongation 20 per cent. in 8 inches. All the roofs will be open boarded roofs covered with green "Precelly" Welsh slates in random sizes. The cement intended for use on this work will be required to pass a sieve of 14·400 meshes to the square inch without leaving more than 10 per cent. residue, the tensile strain of neat cement briquettes 350 lb. per square inch at seven days, and 400 lb. at twenty-eight days, and the specific gravity from 3·00 to 3·15. The amount of water allowed for making the briquettes is 18 per cent. The test for ground lias lime grinding is 900 meshes to the square inch: this the Author has found very much too large, for in one of the tests it was found that one lime when put through the *cement sieve* only left 15 per cent. residue; this is mentioned simply to show that the old specification of 900 meshes for ground lime is now out of date, there being limes now sold that will pass this sieve without leaving an atom of residue. The Author is of opinion that a sieve of 9000 meshes to the square inch might now be specified for ground lime. The windows throughout, except in the cottages, will be wrought steel sashes, with double flanged jambs and heads and single flanged sills 1¾ inch wide. The glazing will be 15 oz. sheet glass fixed in iron with lias lime and whiting in the proportion of 1 lb. lime to 14 lb. of whiting mixed with oil.

The contractors for the buildings are Messrs. Lee and Son, Avenue Road, Aston Manor.

Finally, the Author desires to express his best thanks to

Mr. J. D. Watson, the engineer, for his kindness and consideration in placing at the Author's disposal the opportunity of presenting this paper before the President and Members of the Association.

The estimated cost of the whole scheme is made up as follows:—

CORPORATION OF BIRMINGHAM.

	£.	s.	d.
Destructor house	4,214	0	0
Inclined roadway and boundary walling	3,767	0	0
Drainage, manholes, etc.	100	0	0
Chimney foundation	650	0	0
" above new formation level	1,149	0	0
Outside flue	147	0	0
Refuse furnaces, air fans and engines, and air heaters	4,244	10	0
Hydraulic rams, pump and engine in connection with furnaces	355	0	0
Gas and water services and fittings	187	10	0
Heating, calorifier, steam kettle, oven, etc.	100	0	0
Six clinkering trucks, special design	90	0	0
Tram lines inside buildings for, ditto	50	0	0
Steam lay out	130	0	0
Fixing only storage tank, providing inlet and outlet pipes, overflow, etc., and gas and water department work	105	0	0
Two cottages, weigh office and foundations for weighbridge	950	0	0
Weighbridge	57	0	0
Land	800	0	0
Total for Corporation of Birmingham carried to summary	£17,046	0	0

DRAINAGE BOARD.

	£	s.	d.
Boiler house	1190	0	0
Economiser	185	0	0
Three boilers	1412	12	0
Boiler covering	56	0	0
Steam lay out	1250	0	0
Power station	1287	0	0
Two feed pumps	100	0	0
One feed heater	58	0	0
Two generating sets	2400	0	0
Main switch-board complete, including cable connections	356	0	0
Lighting set	180	0	0
Boundary fencing and entrance gates	60	0	0
Travelling overhead hand crane	128	0	0
Total for Drainage Board carried to summary	£8662	12	0

SUMMARY.

	£	s.	d.
Corporation of Birmingham	17,046	0	0
Drainage Board	8,662	12	0
Total cost of scheme	£25,708	12	0

DISCUSSION.

The **President** moved a vote of thanks to the Authors of the three papers.

Mr. **A. J. Dickinson**: I would like to ask as to the acreage of the area drained by the Board. In the papers the population is given, but not the acreage. Has the putting of Westrumite on the city roads affected the quality of the sewage, that is to say, has it made its presence felt at the works, and can it be identified in the analysis?

Mr. **G. W. Lacey**: I have great pleasure in seconding the vote of thanks to the Authors of the papers. The observations with reference to the construction of percolating beds are very useful indeed. There are several classes of materials used in the beds here, but I do not know whether they have been used a sufficient time to determine which is the best and most satisfactory. I should like to know whether the revolving sprinklers have been satisfactory in work, and whether fixed sprays have been found the best in distribution. They would, of course, only come into operation where there is sufficient head to bring them into use, as they require more head than the sprinklers. The difference in the cost of constructing bacteria beds with the material sloping back and the cost of walling the beds struck me. It does seem difficult to understand that the cost of sloping back should be double that of building a wall. There is no question that the wall is much the better job, as it keeps the bed in position and is neater. With regard to the analyses, I found on working out the percentages of purification in the different beds that in bed A the oxygen absorbed figure was 88 per cent. and the albuminoid ammonia 80·8 per cent.; that in bed B the oxygen absorbed was 77·2 per cent. and the albuminoid ammonia, 68·3 per cent.; in bed C the oxygen absorbed was 80 per cent. and the albuminoid ammonia, 67·5 per cent.; and in bed E the oxygen absorbed was 82·4 per cent., albuminoid ammonia, 74 per cent. These are very good results because I take it the beds are not yet sufficiently matured, but why the A bed should be so much better that all the others, perhaps Mr. Bryan might explain. Then with regard to the A bed, the figures given do not agree with the date. In this case, there is very little difference between the sewage of July 6 and 7, so that it makes no difference in the percentage of purification. But on July 20 the figures of oxygen absorbed should be 18·905 instead of 20·830, and of albuminoid ammonia 0·814 instead of 1·020. That alters the percentage of purification in oxygen from 89 to 87·5, and in albuminoid ammonia from 88·4 to 85·5 per cent.

Mr. J. E. **Willcox**: We have been asked over and over again to give the cost of bacteria beds, and the particulars given to-day will be of very great value. I think the conclusion arrived at as to the cost of walls against sloping sides a valuable one. I have made the same calculations and come to the same results. It is cheaper to build walls than to have sloping sides of the filtering media. I would like to have heard something as to the disintegration of the different classes of filtering media, broken bricks, slag, and clinker. I would like to know whether as good an effluent has been obtained with these as with granite. I will not discuss the vexed question of floors, because Mr. Watson knows that I am not at all one with him as to false floors as against drains, but very excellent results are obtained from both methods.

Mr. J. D. **Watson**: The Birmingham Tame and Rea District Drainage Board was constituted by Act of Parliament. It represents Birmingham, the predominant partner, Aston, Handsworth, Smethwick, King's Norton, Erdington, Sutton Coldfield, and one or two minor places, having an aggregate population of about 850,000 persons. The expenses of treating the sewage are obtained from the various districts by charging so much per rated tenement and levying a precept in one lump sum on each of the constituent authorities.

Within the last few years we have changed our method of treating sewage. Formerly it was treated with lime, and afterwards applied to the land by the systems known as broad irrigation and downward intermittent filtration, but now lime treatment has been done away with, and instead, the sewage—after the road detritus has been taken out—undergoes a process of fermentation in septic tanks before it is used for irrigating the land, or applied to bacteria beds. The sludge question has been one of very great difficulty. The quantity to be dealt with is enormous, and its objectionable smell has appeared up till now to be unconquerable. Unfortunately, we have, to begin with, a sewage which is very difficult to septicise. In ordinary sewage, such as that met with in London, there are five million or more micro-organisms in every cubic centimetre, but here in Birmingham the sewage, as it comes to our works, does not contain more than 300,000 or 400,000 micro-organisms per cubic centimetre. That is largely due to the iron salts and acids contained in the sewage. Recently I have adopted a plan suggested by my friend, Mr. Scott-Moncrieff, of hydrolising the sewage in one set of tanks before passing it into the septic tanks for more complete hydrolysis; but even now we have very great difficulty in producing active fermentation. The valuable information, which is contained in the tables accompanying Mr. Hart's paper, will be of assistance in still further elucidating the sludge problem, and I hope, before the year is over, to be able to say something as to the methods which should be adopted in disposing of sludge that may prove of importance.

In the construction of bacteria beds on a large scale we are also making changes which will be of great value and benefit to the community. The experimental beds are experimental only in the sense of their being different in some respects from each other. They are all capable of dealing with nearly one quarter million gallons of sewage per day, and their area is a quarter of an acre each.

As you will have observed, we have not consoled ourselves with the idea that we have solved the sewage problem. In order to find out which is the best medium to be used, the best size of medium, the best method of constructing the beds, and the best method of distribution, no two beds have been constructed alike. This, in our case, is absolutely essential, as my board are conscious that it will be necessary to extend the system very considerably. The tendency is in this direction, rather than continue the treatment of sewage on downward intermittent filtration beds. I hope before ten years have elapsed to see the whole valley, which is now absolutely covered with crude sewage, as inodorous and verdant as an ordinary farm. While we are going in for bacterial treatment on a large scale, I ought to say that we are not dissatisfied with land treatment. From land we can obtain a purification, on the oxygen absorbed basis, of from 92 to 93 per cent., and I do not expect to get higher efficiency from bacteria beds; but, if we can reduce the area under sewage to, say one-fiftieth of the present area, we minimise the chance of nuisance to that extent. I think, from the experience which we have had of good percolating beds, there can be no doubt that one acre of bed will be sufficient to purify as much sewage as can be purified on from 50 to 70 acres of land, and this can probably be done at less cost; but perhaps the strongest reason for the change of policy is that the drainage board have already acquired nearly six miles of the valley of the Tame (2830 acres), and it is almost impossible to acquire more. While we are thus confined for land, the various towns within the board's district continue to grow at such a rate that, if we were to continue to depend on broad irrigation and downward intermittent filtration, we should have to acquire and lay out an additional 1¼ acre per week. That is a big thing; consequently, it was essential that we should proceed on the new lines, of which you have seen something this morning, and of which I hope you will see more during the afternoon.

In reply to questions which had been put, the first precipitation tanks were constructed about fifty years ago. They were built by the late Mr. Thomas Hawksley, and the more recent tanks and filter beds were constructed by his son, Mr. Charles Hawksley. Samples of sludge were examined, which had been removed from the septic tanks, after four years' continuous use. On analysis, it proved to contain 60 per cent. of inorganic matter, and 40 per cent. of organic matter. It contained traces of gold, silver, and measurable quantities of copper. Dr. Rideal has suggested that it would pay to recover the copper, but I find that to do this, expensive plant would have to be found for the purpose, and I have not information enough to induce my committee to undertake experiments.

We had a very curious experience with the sill over which the septic tank effluent passes on its way to the land. This sill appeared to obstruct the flow of sewage, and on looking into the matter, I came to the conclusion that some mistake had been made with the level. The tank was ordered to be put out of use, and a mason sent to lower the level of the sill by hewing down what appeared to be Derbyshire stone. I was rather astonished to obtain a report from the mason to the effect that the sill was formed of Staffordshire blue brick, entirely covered with an incrustation of lime. My explanation is that the sewage, which must, in former days, have contained lime to the extent of 10 grains per gallon, had formed a sort of stalagmite on the sill.

The inspection of the works began at Meinworth Grange, where the purification works in course of construction, including the regulating chamber, the Dortmund sludge tanks, the experimental bacteria beds, and the primary and secondary percolating beds, were inspected.

The Members then drove to the home farm at Tyburn, where Mr. J. D. Watson most hospitably entertained his fellow Members and the visitors to luncheon. The business proceedings of the Meeting followed the luncheon.

The afternoon was devoted to an inspection of the Saltley Works, including the sedimentation works, the septic tanks, the sludge screening and sludge ejection machinery, and the storm water filters. Mr. Watson answered a number of questions during the inspection of the works.

LANCASHIRE AND CHESHIRE DISTRICT MEETING.

September 24, 1904.

Held at the Council Offices, Withington.

A. T. DAVIS, M.INST.C.E., PRESIDENT, *in the Chair.*

MR. TURNBULL, Chairman of the District Council, received the Members, and offered them a hearty welcome to Withington.

The President, on behalf of the Association, thanked the Chairman of the District Council for the kind welcome he had given them.

The President referred to the great loss the Association had sustained in the death of Mr. E. R. S. Escott, Past-President.

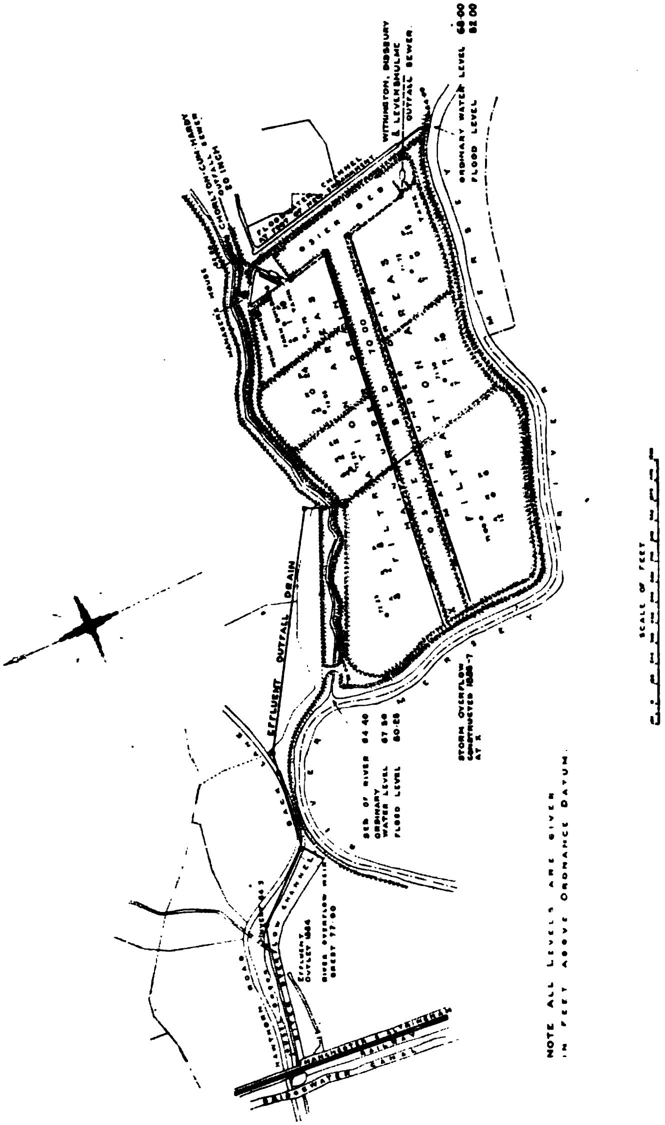
Mr. Brownridge was unanimously re-elected Hon. Secretary for the Lancashire and Cheshire District.

The following papers were read and discussed:—

SEWERAGE AND SEWAGE-DISPOSAL WORKS.

BY JOSEPH SWARBRICK, M. INST. C.E.

THE Author begs, in compliance with the request of the district secretary, to submit this paper as an introduction to that of Mr. A. H. Mountain, Assoc. M. Inst. C.E., the district engineer and surveyor, upon "various works of municipal interest, including a full description of the recently completed sewage disposal works" designed by him and executed under his supervision. The object of this communication is to afford an oppor-



NOTE. All levels are given in feet above Ordnance Datum.

PLAN OF SEWAGE DISPOSAL WORKS AT CHORLTON EES, AS COMPLETED IN 1883–4.

To face p. 80.

tunity of obtaining a description of the schemes of sewerage and sewage disposal, which preceded that recently executed. That duty has doubtless been entrusted to the Author on account of his former official connection with the district, which enables him to speak of various projects under consideration during the past thirty years.

Though not the engineer for the sewage-disposal works which preceded the present ones, he was from their inception privileged to be associated both with their author and the engineer who supervised their execution.

The faithful historian who attempts to deal with any scientific subject, after a lapse of a quarter of a century, has a somewhat delicate task to perform, if he seeks, in the interests of science, to reveal the whole of the facts which are so essential to a complete comprehension of any subject. In the present case, the advisers consulted were all men whose wide experience was at that time an ample assurance that the opinions which they expressed were consistent with the latest achievements of municipal engineering. Had they been permitted to practise in these days, none would have been more progressive than they in the adoption of new principles in the design of any works entrusted to them.

The Withington district (which is about to be added to the city of Manchester) covers an area of 5728 acres. It was first placed under the jurisdiction of one authority for sanitary purposes in August 1872. In 1863 the population was 6273, and the rateable value 34,420*l*. Ten years later the number of inhabitants had increased to 12,850, and the rateable value to 82,110*l*. The present estimated population of the district (inclusive of the officers and inmates of the workhouse) is upwards of 40,000, and the rateable value is 258,888*l*. The sewage of the adjoining urban district of Levenshulme has also been treated at the outfall works at Chorlton-cum-Hardy since 1885. The area of the joint district is 6334 acres, and the estimated population 54,000. Prior to the constitution of the rural sanitary authority, the district had but one short length of recognised public main sewer, namely, the Didsbury outfall sewer constructed as a relief work during the cotton famine in the early sixties. Its outfall was direct into the river Mersey near "The Beeches." Another sewer was laid (about the same period) jointly by the landowners and the turnpike trustees along Nortenden New Road (Palatine Road), and discharged direct into the river Mersey.

In 1873, when the newly constituted sanitary authority was formed, the crude sewage contributed by a population of 12,850 was being discharged direct into either the river Mersey or its tributaries. It soon became imperative that a scheme for the interception of the sewage must be considered. Some of the most valuable residential property in the district was situate in close proximity with the outfalls into the river. Almost every minor stream had been converted into an open sewer. The Rivers Pollution Prevention Act, 1876, had not then passed into law, but its provisions were being anticipated, and the rural sanitary authority from the outset saw that any scheme of sewerage adopted must be such that was consistent with the proper treatment of the sewage before its discharge into the river Mersey.

In January 1874, Messrs. Cawley and Newton, civil engineers of Manchester, submitted to the rural sanitary authority their first report upon the main drainage of the Withington district. The scheme recommended, if carried out in its entirety, would have involved an estimated expenditure of 55,000*l.* It was proposed to carry the main outfall sewer as far as Flixton, provided that experience proved that irrigation was the proper mode of disposing of sewage, as there was no land or very little available for the purpose nearer than that above the confluence of the Irwell and the Mersey.

The engineers were also asked to advise "as to the best methods of disposing of sewage." It is now of historical interest to record in their own words their views at that time upon the subject. They said: "We must confess that on this point we are not prepared yet to give a decided opinion, but are in the hopes that before long experiments which are being made will enable a more accurate judgment to be formed. We believe that in many cases sewage is and may be applied to irrigation with advantage and without nuisance, but we are aware that the greatest care and judicious management are necessary to ensure these results, and that frequently there is cause of complaint. As to other modes of dealing satisfactorily with sewage, we do not think that sufficient data exist for forming a sound impartial opinion, and therefore we wish to postpone our decision on that point."

Now, after a lapse of 30 years, we have a Royal Commission appointed several years ago, still reserving its final decision upon this same question: "What are the best methods of disposing of sewage?"

The population of the district in 1874 was, as stated, 12,850. The proposed outfall sewer up to Chorlton-cum-Hardy was to have had a discharging capacity of 35 million gallons per day, where it was proposed to discharge by an overflow whatever exceeded 16 million gallons per day. The engineers considered that "it was scarcely probable that the population could reach 100,000 in the next 50 years (1924), but assuming it to do so, and the average number per acre to be 150 persons in the urban portion, it would be equivalent to draining a town population of 670 acres. The sewage proper from 18,200 houses, which they would occupy, would not reach 2 million gallons per day." During the interval of 30 years the population has increased to upwards of 40,000, but for sewage purposes the contributing population is 54,000, on account of the sewage of the urban district of Levenshulme flowing into the Withington sewers. The present average daily dry-weather flow approaches 3½ million gallons. The cause of that will be referred to hereafter.

The rural sanitary authority practically consisted of four guardians elected for other duties. The authority felt great reluctance in accepting the responsibility of spending upon main drainage works 55,000*l*. on behalf of a district having then a rateable value of only 82,110*l*. In March 1874, the authority sought an interview with the President and Secretaries of the Local Government Board, to whom they explained their difficulties. That resulted in the holding of an official inquiry nominally as to the desirability of constituting a local board, but in fact, as to the merits of Messrs. Cawley and Newton's scheme. Great opposition was raised to the proposal to constitute a local board, as well as to the adoption of the scheme. The inspector expressed, informally, a qualified approval of the scheme, *except the extension to Flixton*. That expression of opinion, as will be seen hereafter, had a potent influence upon the future local authority of the district when they were compelled to take decisive action.

It may be of interest to state that during the summer of 1874 Captain Leirnur's pneumatic system of drainage then in operation at Amsterdam and Leyden was brought under the notice of the rural sanitary authority. Captain Leirnur was invited to advise, which resulted in his submitting two projects, estimated to cost respectively 62,500*l.* and 65,000*l.*, besides which they would have involved an additional annual outlay for working expenses (inclusive of depreciation) of 1710*l.* Those Members who saw the system working in Holland entertained a very favourable opinion of it. It was, however, found that the system could only be adopted here under serious disadvantages, and the local difficulties prohibited its adoption.

There was yet another scheme of drainage considered, which embraced the southern suburbs of Manchester, which was prepared by a well-known local civil engineer, the late Mr. R. W. Barnes. None of these schemes were, however, adopted.

In 1876 the rural sanitary authority was superseded by a local board, which was constituted in September of that year. Threats of legal proceedings against the newly constituted local authority speedily convinced that body that it was not likely to be permitted to indulge in the pleasures of masterly inactivity. The combined pressure of riparian owners and of the Local Government Board, who declined to sanction any expenditure for much-needed private improvement works until an assurance was received that no time would be lost in carrying out a complete scheme of sewerage and sewage disposal, forced the local board to take action. The late Mr. John Newton, M. Inst. C.E., of the firm of Messrs. Cawley, Newton and Smith, civil engineers of Manchester, was instructed to report. Mr. Newton was requested to consider (*a*) all possible outfalls and modes of dealing with the sewage within the district; (*b*) beyond the district; (*c*) to advise as to the desirability of joining the proposed Manchester scheme, prepared by the late James G. Lynde and J. F. Bateman, MM. Inst. C.E. The report when submitted afforded a selection of seven different schemes, four of which were seriously considered by the Local Board, viz.:

Scheme.	Estimated Total Cost.
	£
Chorlton Ees (irrigation)..	41,900
„ (precipitation)	57,900
Flixton scheme	59,900
Manchester scheme	61,400

Of the foregoing schemes, there were but two which were really practicable. They were the Chorlton Ees scheme (provided sufficient land had been acquired), which was adopted in a mutilated form, and the Flixton scheme. The Chorlton scheme (irrigation) as proposed, suggested the acquisition of 179 acres of land, of which 100 acres were to be laid out in the first instance. The Flixton scheme was virtually that outlined in the report to the rural sanitary authority in 1874. About 400 acres of low land immediately above the confluence of the Mersey and Irwell was to have been acquired. The outfall sewer was suggested at such a depth below the surface as would have been available for the districts of Moss Side, Stretford, and Urmston. For Withington, it was suggested to lay out about 100 acres; as was also proposed in the case of the site at Chorlton-cum-Hardy.

There was at that time so much uncertainty as to when the Manchester Corporation was likely to be galvanized into a state of activity regarding the question of sewage disposal, that Withington, with the obligations imposed upon it, could not apparently postpone the question indefinitely, as Manchester was then doing. It was not until September 1888 (ten years later) that the first Local Government inquiry was held, at Manchester, in reference to a sewage disposal scheme for the city. Another factor which influenced the local board in determining not to enter into negotiations with the city, doubtless was the advice of their engineers to the effect that an independent scheme would be the most economical.

Having submitted the schemes to the authority with lucid explanations as to the merits and demerits of the several projects, the engineer's responsibility ceased. It remained for the local board, acting under the control of the Local Government Board, to decide which scheme should be adopted. The majority upon the local board was very largely governed by the action of the central authority regarding the Flixton scheme when previously recommended to the rural sanitary authority in 1874.

At that time, it will be remembered, the inspector "expressed informally a qualified approval of the scheme, *except the extension to Flixton.*" That expression of opinion led the local board to suppose that the Flixton scheme would not be approved, and, seeing that it was the most costly scheme, it needed little to prejudice the newly constituted authority against it. There was, however, a determined minority representing Chorlton-cum-Hardy that fought most strenuously against the Chorlton

Ees scheme, both upon the local board and at the Local Government inquiry, advocating the alternative more costly scheme. Under all the circumstances of the case it is not surprising to find that the local board approved of the Chorlton Ees scheme in 1879, and obtained the approval of the Local Government Board to its execution.

At the Local Government inquiry the opposition of residents and land owners succeeded in imposing upon the local board conditions which had a most serious effect upon the scheme of Messrs. Cawley and Newton. Instead of being able to acquire 179 acres of land, compulsory powers could only be obtained to acquire 72 acres. Up to that time it had been supposed that the quantity of sewage might be determined by assuming it to equal a water supply of 20 gallons per head per day. The population was estimated (1878) at 15,000; the daily volume of sewage at 300,000 gallons. The population was, however, fast increasing, and in 30 or 40 years it was said that it would probably reach 50,000. The engineers stated that, "It was a debatable point as to the degree of dilution which could be considered unobjectionable, and it must be determined in each case by reference to the size and nature of the stream into which diluted sewage is discharged." They adopted ultimately 4 times the dry-weather flow from a population of 50,000 (taken at 1,000,000 gallons per day) in determining the discharging capacity of the main outfall sewer. The size of the outfall sewer proposed was 3 feet by 2 feet with a fall of 1 in 1500, with an estimated discharging power of 5,000,000 gallons per day.

In the interval which elapsed between the promotion of the original Chorlton Ees scheme and the acquisition of the reduced area of land, great diversity of opinion was expressed as to the advisability of attempting to treat the sewage of the district upon the small area ultimately available. Some members of the Board obtained information as to the works designed by the late Mr. John Bailey-Denton, M.Inst.C.E., at Abingdon, Kendal, Barnsley, Dewsbury, and other places, where he had adopted the principle of "downward intermittent filtration" through deeply drained suitably constituted soil. It had already been realised that of the 72 acres acquired only about 50 to 60 acres would be available for the treatment of sewage, which implied that the sewage contributed by 1000 persons would ultimately be applied to each acre of the filtration beds.

The board sought the advice of Mr. Denton as to the laying out of the land, and he, acting upon the instructions supplied to him by certain members of the Board, reported as follows:—

"About 50 acres of the land should be prepared for the ready absorption of the *dry-weather outflow calculated at* 1,000,000 *gallons daily*, while the remainder should be formed into beds and planted with prickly comfrey and osiers to receive and clarify any sewage (when diluted above 1,000,000 gallons) which the land, when suddenly covered, will not absorb."

It will be observed that no reference is made in any of the reports quoted regarding the actual dry-weather flow of sewage discharged from the then existing sewers. The fact was, that when the engineers were instructed there were no available plans or sections showing the actual positions, dimensions, or levels of any of the sewers. Few manholes existed upon them, and it was impossible in the short time at the disposal of the engineers (even had the board been prepared to incur considerable expense in sinking upon sewers laid in treacherous ground) to obtain actual gaugings.

Mr. Denton, who received the whole of his preliminary instructions direct from a consultative committee, was obliged to rely absolutely upon the data supplied to him by men who did not claim to be experts. He therefore believed implicitly that the ultimate dry-weather flow in 30 or 40 years would not exceed 1,000,000 gallons daily. He was also not made aware, at that time, of the fact that the Withington Board contemplated entering into an agreement with the Levenshulme local board to treat a volume of sewage not exceeding 935 gallons per minute whenever that district (then sparsely populated) so extended as to yield that volume.

It is necessary, in order to fully appreciate future developments, to bear this fact in mind.

It was under these circumstances that an authority that had been thwarted in acquiring a sufficient area of suitable land, in perplexity sought the advice of Mr. Denton, and determined to entrust him with the laying out of the sewage farm at the Chorlton Ees.

The Author, who was at this period officially connected with the district, had then no connection with the drainage scheme, being fully occupied with multifarious duties imposed upon one in charge of a newly constituted district; where, in addition to much routine work, he was speedily engaged in Parliamentary applications and oppositions as to tramways, negotiations as to one railway, opposition to another, obtaining way-leaves for sewers, various public improvement works, securing sites for offices and depots, as well as advising as to the conduct of an architectural competition for new public offices, much larger than those subsequently erected.

One of Mr. Denton's first recommendations upon his appointment was that the board should be their own contractors. Upon his advice Mr. Samuel Johnson was appointed as superintendent of the works, and later the Author was associated with Mr. Denton in connection with the outfall works, it having then been determined that the construction of the main sewerage works was to be executed under the Author's directions, in accordance with the scheme of Messrs. Cawley and Newton, subject to certain modifications recommended by Mr. Denton, to bring the scheme into harmony with his recommendations as to the disposal works. Having in carrying out various works subsequent to 1877, discovered that the sewage in many of the existing sewers was highly diluted with subsoil water, the Author from time to time availed himself of every opportunity of gauging the overflow from the various contributing sewers, so that by degrees he was able to collect a sufficient number of actual gaugings to arrive at a reliable estimate of the minimum dry-weather flow of sewage likely to be received at the outfall works on completion. These observances were in due course submitted to Mr. Denton, with the result that we were jointly instructed to advise upon the best practicable means of limiting the discharge upon the sewage works and of dealing with the storm water. But there the matter ended.

DESCRIPTION OF THE SEWAGE-DISPOSAL WORKS EXECUTED 1880–1883.

The area of land actually acquired was 78 acres; 57 acres were available for the treatment of sewage. The particulars of the area of the farm as laid out were as follows:—

	a.	r.	p.
Filtration area	49	0	22
Osier beds	8	0	3
Embankments, water, etc.	15	3	25
Land outside the farm	4	3	30
Total	78	0	0

The farm proper may be said to have had an area of nearly 73 acres. The site is bounded on the north by the Chorlton brook, on the south and west by the river Mersey, and on the east by an earthen embankment 10 feet in height, battered 2 to 1 and 1½ to 1 to form a protection against flood-water (to which the land had previously been subject) in case of the bursting or overflowing of the river banks above the farm.

Throughout, the subsoil consisted of a deposit of alluvium, never previously effectively drained. Its character varied on different parts of the land. Although numerous trial holes were dug before the land was acquired, its true nature was not determined until the under-drainage works were executed. Speaking generally, the north side was much more retentive than the south side. From the first this was so apparent that the under-drains on the north side were placed 33 feet, and those on the south side 150 feet, from centre to centre.

The main effluent outfall drain was 930 yards in length, 30 inches in diameter, laid to an inclination of 1 in 2000. It passed through a cast-iron syphon 60 feet in length, under the Chorlton brook, and discharged into a small watercourse called the "Ousel brook," which flows within an artificial flood-channel, several miles in length, constructed many years ago for the relief of the river Mersey, at a point some distance above the Bridgewater Canal.

The under-drainage of the farm was laid at a minimum depth of nearly 5 feet below the level of the filtration areas, and was constructed chiefly of circular-socketed glazed pipes, varying from 6 inches to 18 inches in diameter. This work was executed at a time when one frequently heard the advocates of shallower drains contend against the system adopted. The Author can, however, bear testimony to the fact that the porosity of the subsoil was vastly increased by Mr. Denton's works. In many instances the exuberant growth of the crops over the under-drains and for some distance on either side demonstrated most clearly the value of under-drainage, from the standpoint of the agriculturalist.

The filtration areas were divided into beds about 9 feet wide, parallel with the drains. They were separated by distributing grips 2 feet in width. The osier bed, 8 acres in extent, was intended to be used only for the reception and treatment of the storm-water in excess of the regular dry-weather flow.

The sewage entered the farm at its north-eastern and south-eastern extremities by two outfall sewers, each discharging into separate sets of screening tanks, from which it passed through underground 18-inch circular socketed fireclay pipe conduits, and was delivered in a crude state upon the land from one or more distributing chambers upon each filtration area.

The Author's observations showed that the flow in the effluent outfall was equal to 48 per cent. of the volume of sewage distributed upon the filtration areas, plus the rainfall thereon.

The average cost of the land (inclusive of tenants' compensation) was about 157*l.* per acre. The cost of the sewage farm was equal to 22*s.* 9*d.* per head of the contributing population, in 1885. The average cost of under-drainage was 35*l.* per acre. The cost per acre of sewaged land for tanks and distribution was 18*l.* 15*s.*; the average cost per acre of the farm for the whole of the works was 115*l.* 10*s.*

So far, the Author has alluded only to the historical phases of the earlier sewage disposal works at Withington, and the manner in which the works were executed. The object of the Members of this Association in visiting each town is to obtain actual facts concerning municipal undertakings. The Author, though one of the oldest Members of this Association, has for many years devoted himself to private practice, but for ten years he has been a member of the local authority and has had the works referred to under his observation.

When the engineer who laid out the farm was consulted, he was asked by the late local board to deal with the land on the assumption that there would be an immediate daily dry-weather flow of 300,000 gallons which might be increased to 1,000,000 gallons daily.

The actual gaugings of the sewers taken by the Author, after he was requested to act in connection with the sewerage works, subsequent to the appointment of the engineer for disposal works, revealed the fact that when the whole of the dry-weather sewage to be delivered upon the Farm was intercepted it would not be 300,000 gallons but nearer 1,800,000 gallons or six times the water supply at that time. To increase the difficulty of the situation, the newly constituted board, anxious to obviate the nuisance which might have arisen if Levenshulme had established an outfall works within the

Withington district, entered into a provisional agreement binding themselves to treat the Levenshulme sewage at the Withington sewage works at Chorlton-cum-Hardy. Although the population of Levenshulme at that time was only 3500, it has since been quadrupled, and the agreement provided, upon certain terms, for the treatment of a volume not exceeding 935 gallons per minute. For a similar reason at a later date, (previous to the delivery of the Withington sewage on the land) negotiations were actually commenced between the local boards of Withington and Rusholme with a view to treating the Rusholme sewage as well. In that case the Author was, however, consulted; and he succeeded in showing that the only conditions upon which Withington could undertake the obligations of Rusholme were such that it would be better for Rusholme to adopt the other alternative which was open to it of arranging for Manchester to take its sewage; which, indirectly, had the effect of causing that district to be included within the City boundary. Otherwise the difficulties of Withington would have been still further increased.

Sewage was first passed upon the land through the 20-inch cast-iron main from what is locally known as Lord Egerton's sewer, then draining the Whalley Range section of the district, on January 10, 1884. The sewage was highly diluted, and in exceptionally dry weather the flow was about 300,000 gallons per day, but during dry weather whilst the subsoil was saturated the daily yield of that sewer alone was regularly 600,000 gallons. Whenever heavy falls of rain occurred, the storm overflow into the Chorlton brook was speedily brought into action, and any storm-water passed on to the land was discharged into the osier bed and thence into the river Mersey. Between the first delivery of sewage upon the land and the discharge of the whole volume of 1,800,000 gallons from an estimated population of 21,000 an interval elapsed of rather more than a year. In the interval crops were cultivated with reasonable success. The effluent throughout that period was perfectly satisfactory; but it was evident to a close observer, that owing to the retentive nature of fully one-half the area of the land, it was being worked to its full capacity. The wisdom shown by Mr. Bailey-Denton in laying deep drains was fully proved. On the one hand, there was no question that the sewage did filter *through the soil* to the drains; and the depth of cracks on the surface of the land, during continuous hot weather, showed that had the drains been shallower the sewage would of necessity have reached them without proper filtration through the soil taking place.

During 1885 the whole of the daily outflow of 1,800,000 gallons was delivered upon the land, and from that date until the completion of the new bacteria beds recently constructed by Mr. Mountain, the Author ventures now to assert that the effluent has never been satisfactory.

The local board of 1885 found themselves in a real dilemma. Few of the members knew the history of the scheme they had brought to completion. The earlier scheme, with an outfall at Flixton, which would have saved them from their trouble, was unknown to most of them. The reduction of the area at Chorlton Ees from 179 acres to 72 acres, to meet the wishes of residents and opposing land owners, had been forgotten. Even those who had advocated the reception of the Levenshulme sewage, to avoid establishing an outfall works in the Withington district, could not realise the seriousness of their action under the altered conditions. In those earlier years it was the habit of the board to leave to a consultative committee such matters as the sewage disposal. Committees of that kind frequently feel themselves justified in acting upon their own initiative after visiting various other works, often differing in essential features from those required for the district under their consideration. The farm at Chorlton was literally flooded out during wet weather. Storm-water, of course, passed into the river untreated. At this period a farm manager was appointed who possessed a knowledge of farming and broad irrigation. The committee soon decided to cause a relief-outlet to be made at one end of the osier bed. The number of drains upon the farm was speedily trebled. The new ones were laid within 3 feet (instead of 5 feet) of the surface. The soil upon them was only "punned" 1 foot in thickness, instead of up to the surface as formerly. Some were covered with cinders. During the winter of 1885–6 about 40 acres of the carefully-drained filtration areas, laid out with the utmost precision under the supervision of Mr. Bailey-Denton, were treated in this manner. From that time the land was capable of *clarifying* a much larger volume of sewage, but the effluent discharged into the "Ousel brook" was never so pure as it was previous to the execution of those works. So constant were the complaints, that a little later a supplementary outfall had to be made, under Mr. Mountain's direction, which discharged into the Chorlton brook whenever the surface level of that stream would permit of its use.

In 1895 the present district council found themselves coping with increased difficulties. The populations of both Withington and Levenshulme had increased considerably—then having reached about 50,000. The daily outflow was no longer 1,800,000, but anything between 2,500,000 and 3,000,000 gallons per day.

The late Sir Robert Rawlinson, C.B., stated that, in his opinion, "12,000 tons of sewage per acre per annum, equal to 120 inches in depth, might be used on well-prepared land without swamping it." In 1888 the Author showed that an attempt was being made to apply $4\frac{2}{3}$ times that quantity to the filtration areas at Chorlton Ees; and in recent years, had the whole of the sewage discharged been applied, it would have been equal to delivering about 8 times that volume upon the land, having regard to the periods of rest which must be given to all filters —whether natural or artificial.

During 1896 it became imperative for the district council to proceed with works for the prevention of flooding in many parts of the district, as well as to satisfy the requirements of the Mersey and Irwell Joint Committee regarding the quality of the effluent.

About that time the Author was asked to accept the chairmanship of the main drainage committee. Forthwith Mr. Mountain was instructed to formulate a comprehensive scheme, and in September 1897 his first scheme was submitted. Although only seven years ago, very little was then known of the practical application of bacterial treatment to the purification of water-carried sewage. That method of treatment had not advanced beyond the experimental stages. In his first report Mr. Mountain advised chemical-precipitation and subsequent filtration through land, which was the method then favoured by the Local Government Board wherever sufficient land for filtration purposes could not be obtained. Those who had been studying the vexed question of sewage treatment were becoming conscious that we were upon the verge of a new era. The distinction between mechanical and bacterial filtration had been discerned. The advocates of the biological treatment of sewage in artificially constructed filters, now known as "bacteria-beds," were showing marvellous experimental results. The discovery that local authorities, unable to acquire sufficient suitable soil for sewage purposes, could, without the aid of patented precipitants or mediums for filtration, not merely clarify, but, in fact, substantially purify water-carried sewage, has, in the past ten years, completely revolutionised our ideas regarding sewage treatment.

Personally, the Author could not, in 1897, approve of any scheme of chemical treatment, plus land filtration, because there was no financially practicable method of chemical treatment known which could have been relied upon to produce an effluent free from liability to set up secondary decomposition. The proposal to improve the effluent by subsequent filtration through the land available was likewise not feasible in consequence of the highly polluted condition of the "sewage-sick" soil. The only conceivable way of proceeding, if suitable land had been obtainable at a reasonable expenditure, would have been to acquire a vastly increased area. That was believed also to be impossible. It was under those circumstances that the Author advised that attention be paid to the study of the bacterial methods of treatment, and that the whole question should be referred to some independent eminent engineer having had municipal experience. The council unanimously adopted the recommendation. Visits were made to most of the places where experimental plants had been laid down. Subsequently a small, simple, inexpensive, double-contact, experimental bacteria-bed was constructed by Mr. Mountain at Chorlton Ees. It worked with most satisfactory results. The scheme was submitted to Mr. James Mansergh, Past-President Inst. C.E., for consideration and report. He and Mr. G. R. Strachan, M. Inst. C.E., then associated with Mr. Mansergh, gave the question most careful consideration during a period of about twelve months. Ultimately Mr. Mansergh made important recommendations concerning the sewerage and flood-prevention works, and finally he recommended the adoption of a scheme of sedimentation tanks and bacteria beds for the treatment of the dry-weather flow of sewage, as well as storm-water filters to treat the first discharge of storm-water.

Mr. Mountain in the scheme executed has adopted the principles laid down by Mr. Mansergh. He has now completed the sewage purification works in a most substantial manner.

The effluent discharged fulfils the requirements of the Mersey and Irwell Joint Committee. Mr. Mountain will personally explain the works executed. The Members of the Association will be afforded an opportunity of viewing them and forming an opinion as to their efficiency.

In conclusion, the Author begs to acknowledge his indebtedness for many of the facts related in this paper, which he fears has now become far too long, to the following sources of information. The statements made from time to time by the late E. H. Fuller, Esq., J.P., Chairman of the Chorlton R.S.A., and first Chairman of the Withington Local Board; the several reports of the late firms of Messrs. Cawley and Newton, MM. Inst. C.E. (subsequently Messrs. Cawley, Newton and Smith); the reports of the late Mr. John Bailey-Denton, M. Inst. C.E.; as well as to Mr. A. H. Mountain, Assoc. M. Inst. C.E., and others, for their assistance.

THE MUNICIPAL WORKS OF WITHINGTON:

WITH A DESCRIPTION OF THE NEW SEWERAGE SYSTEM AND SEWAGE OUTFALL WORKS, ON THE DOUBLE-CONTACT BACTERIAL SYSTEM.

By A. H. MOUNTAIN, Assoc. M.Inst. C.E.

General Description of the District.

The area of the Withington Urban District Council's district is 5728 acres, or 9 square miles, and the population at the present time is estimated at 40,000. It is situated adjoining the southern boundary of the City of Manchester and the urban district of Moss Side, and may be considered to be the principal suburban residential district adjoining the city. The rateable value is 258,888*l.* It was constituted a local board in 1876, and became an urban district council under the Local Government Act, 1894.

The district is divided into six wards, which each return three members, one of whom retires annually.

The geological character of the district is, as to the southern part, gravel and sand of an average depth of 12 feet, resting on boulder clay; and as to the northern portion, red sandstone, underlying a thin stratum of gravel and clay.

There is a surface gradient from the northern portion to the southern portion of the district of about 50 feet, the average height above ordnance datum being, on the north of the district, 150 feet, and on the south of the district, 100 feet.

Highways.

The length of county main roads is 4½ miles; the length of county secondary roads, 7 miles 5 furlongs; and of highways (not including passages), 22½ miles; and of passages and back streets, 6 miles 2 furlongs.

The greater portion of the main roads and secondary roads are made up with ordinary macadam; and the newer highways, made up under Section 150 of the Public Health Act since 1876, with East Lancashire sett paving. All back passages are flagged and back streets paved with setts. Some fifty private streets have also during the past twelve years been paved with tar macadam. The staff of workmen engaged upon the maintenance and repair of highways consist of five paviors, four stone-masons, and ninety labourers, with sixteen carters. The Council has two steam road rollers—one, of 12 tons weight, by Aveling and Porter, of Rochester; and the other, 15 tons, by Green, of Leeds. The Council has twelve water vans and barrels.

The peculiar character of the Council's district, consisting of five centres of population separated by agricultural land, renders necessary several depots, the principal one of which is in the rear of the town hall. There are also depots at Chorlton-cum-Hardy, adjoining the railway station; at Didsbury, near that station, and three others in other parts of the district.

The district being mostly of a residential character, tar macadam has been much in favour during recent years, but the Author, from his experience, has not found it altogether satisfactory, and considers that it should be used only in streets of light traffic. He has found the difficulty of repairing this class of road to be very great, since it can only be carried out in suitable dry weather, and he has also found it to be expensive. Its advantages are, no doubt, great in a residential district such as Withington, where quietness may reasonably be considered to outweigh the disadvantages of its cost.

Various specifications for tar macadam have been adopted from time to time, but the most satisfactory material consists of limestone. Granite has not sufficient affinity for the tar compo.

Both paved streets and tar-macadam roadways are made up on a 12-inch underbed, consisting of clinkers and broken stone steam rolled to a smooth hard surface.

The flagging of streets has been, up to recent date, of East Lancashire or Haslingden flags, commonly known as "Best Barns," at least 3 inches in thickness, laid and jointed in hydraulic lime mortar. Some few streets have recently, however, been flagged with artificial flags, some made by the Shap Granite Co., some are Jones's annealed, and others of the Council's own make.

All private streets, back streets and passages are, on completion, declared public highways, except in certain special cases.

The district not being provided with a separate system of sewerage, all streets and passage gullies are connected to the main sewers.

The following table shows the value of the works executed under Section 150 of the Public Health Act, 1875:—

	£
1890	2,681
1891	5,709
1892	4,489
1893	4,462
1894	11,162
1895	5,843
1896	2,620
1897	8,323
1898	8,144
1899	9,867
1900	6,415
1901	8,250
1902	10,206
1903	17,900
1904	7,843
	£113,914

The Author is glad to say that the whole of the amounts apportioned on the frontagers have been recovered, with one or two exceptions where the owners have left without trace, or other circumstances have occurred, and this without litigation.

The following table shows the average prices paid for the classes of street works mentioned for the past fourteen years:—

	s.	d.	
1890.			
6 inch sett paving, including underbed	5	0	per square yard
B. B. flagging	5	0	„
Kerbing	3	6	per lineal yard
1895.			
6 inch sett paving	4	8	per square yard
4 inch dry and 4 inch tar macadam	4	3	„
2nd B. flagging	5	3	„
6 inch sett channel	5	0	„
Kerbing	3	9	per lineal yard
1900.			
6 inch sett paving (in pitch)	6	3	per square yard
4 inch dry and 6 inch tar macadam	4	6	„
B. B. flagging	6	9	„
6 inch dressed sett channel (in pitch)	8	0	„
Kerbing	4	6	per lineal yard
1904.			
6 inch sett paving (in pitch)	6	0	per square yard
6 inch tar macadam	4	6	„
B. B. flagging	6	6	„
2½ inch concrete flagging	4	3	„
6 inch dressed sett channel (in pitch)	7	6	„
Kerbing	4	0	per lineal yard

Average price per lineal foot of making up a 12 yards wide street:—

	s.	d.
1890	12	0
1895	13	6
1900	16	0
1904	16	0

SEWERS.

Generally speaking, the sewers of the district consist of stoneware and earthenware socketed pipes laid in straight lines from manhole to manhole, with joints made with tarred gasket and Portland cement, the main trunk and outfall sewers only being of brick. All sewers up to 9 inches diameter are water-tested when completed; manholes are provided at intervals not exceeding 100 yards, with chambers 4 feet 6 inches long, 2 feet 3 inches wide and 5 feet high. Special iron shaft ventilators have been provided in certain special cases, but generally the ventilation is by perforated covers at the street surfaces.

Owing to the comparatively level character of the district, there are many flat sewers having gradients from 1 in 200 to 1 in 1000. In order to provide for the thorough flushing of these a portable flushing tank, having a capacity of 1700 gallons, is found most useful. The flushing tank has a galvanised steel telescopic tube, which is lowered into the manhole when flushing is about to take place. This tube has a quarter bend at its lower extremity, which is directed as required, thus delivering the water with full effect in the direction of the sewage flow.

DRAINAGE OF NEW HOUSES.

All drains of new properties are inspected and tested with water up to the water-closet pan on the first floor, and an inspector devotes his whole time to this work. It is also the duty of this inspector to prepare a tracing from the approved building plan of each property, showing the exact position and depth of the drain as laid, so that reference can at any future time be at once made to the exact position thereof.

The water used in testing is taken from the town's mains.

BY-LAW PLANS.

All plans for new properties are deposited with the Author, in duplicate, and reported upon in writing by him to a sub-committee, which meets monthly and goes through them in detail, approving or making recommendations thereon to the Council.

The building inspector sees that all footings of walls are properly constructed, damp courses in position, walls and timbers of correct thickness and dimensions, and that the by-laws generally are observed.

The houses are certified by the Author upon receipt of the inspector's report in writing that the same are completed and fit for habitation. The following Table shows the number of dwelling houses certified during the last fourteen years:—

1891	133
1892	140
1893	184
1894	135
1895	245
1896	284
1897	412
1898	404
1899	423
1900	440
1901	330
1902	327
1903	326
1904 (to date)	278
Total	4061

LIGHTING OF THE DISTRICT.

The street lighting of the district is, generally speaking, by ordinary street lamps burning 4 cubic feet per hour, there being 1470 lamps in all, and sixteen lamp-lighters are employed. The principal streets and important junctions of roads are lighted by incandescent lamps; the gas used is supplied by the Manchester Corporation; this department is under the control of the superintendent of lamps, ashpits, etc.

REMOVAL OF DOMESTIC REFUSE.

There are in the district 8315 ashpits and portable dustbins. The latter have come much into use during the last few years, and are of course greatly preferable to the filthy fixed ashpits. Much attention has been given by the health committee and the medical officer of health, Dr. Railton, to the removal of the old combined privies and ashpits, and the substitution therefor of water closets and portable bins. The number of labourers employed on this work is twenty-six, with fifteen carters.

The whole of the refuse of the district is removed to the destructor at Nell Lane and to the sewage works for use in steam raising at both places. Prior to 1895, when the destructor at Nell Lane commenced work, the ashpit refuse was used for filling up holes and levelling up ground in various parts of the district. The medical officer of health having for many years strongly condemned this system, and difficulties in obtaining tips free from objection becoming insurmountable, the Author was instructed to prepare plans for the present destructor, and it was duly erected and completed in 1895, since which time tipping has been discontinued.

DESTRUCTOR AND CONCRETE FLAG-MAKING PLANT.

As before mentioned, the refuse destructor in Nell Lane was erected in 1895 to the Author's designs, and stands upon a site containing 2 acres of land adjoining the Manchester Southern Cemetery, about 400 yards from Barlow Moor Road and near the Manchester Crematorium. The total cost of the destructor was 7105*l.*, including land (857*l.*), sewering, and road-making.

The destructor consists of 6 cells in one range, each cell having a grate area of 50 superficial feet, the main flue being 7 feet 6 inches wide, and passing under the rear of each cell. The feeding floor is 4 feet below the tipping beam.

As originally designed, a multitubular boiler 11 feet by 7 feet was provided to drive a mortar mill and dynamo for lighting the works.

The cells are worked by natural draught, the top of chimney being 150 feet above ground level, and having an interior firebrick lining 4 feet 6 inches diameter to a height of 80 feet. The cells are provided with rocking bars, which are worked by means of horizontal levers; the amount of refuse consumed in each cell per day of 24 hours is 5 tons. Three stokers are employed on the day shift and two at night.

The destructor yard is sunk about 10 feet below the ordinary ground level, the incline to the tipping shed being 1 in 38 and from the destructor yard 1 in 30.

In November 1897, owing to the high price of flags, and in order to make use of the clinkers from the destructor, the Author recommended the Council to lay down a hydraulic plant for the purpose of making concrete flags. The scheme was adopted and the plant duly installed. The manufacture of flags commenced in September 1898, since which time it has been continuously proceeded with. The hydraulic presses and plant were supplied and erected by Messrs. Fielding and Platt, of Gloucester, and have been very satisfactory in their working. The various main roads and highways, and also private streets, have been paved with these concrete flags, which are very satisfactory in colour and durability up to the present time. The cost of making them amounts to 1*s.* 11·84*d.* per superficial yard in the proportions below:—

Wages	·517
Cement	·323
Granite chippings	·076
Repairs, oil, packing, etc.	·039
Paper, linen, tin, etc.	·032
Sand	·013
	1·000

The proportions of materials used in the flags (by measure) are as follows:—

For the face of the flag (¾ inch in thickness) 1 part granite chippings, 1 part of sand, 1 part of best quality Portland cement.

The body of the flag consists of 3 parts of ground clinkers (crushed in the mortar mill), 2 parts of clean sharp sand, and 1 part of Portland cement.

The flags are all made 2½ inches thick, and are allowed to mature for at least six months before being used. The total cost of the plant and buildings connected therewith amounted to 2250*l.*

Six men are employed at flag-making and removing and stacking.

TRAMWAYS.

The existing tramways are laid from the Manchester boundary in a southerly direction, along Wilmslow Road and Palatine Road to the Terminus on the Midland Railway Bridge near the Town Hall at West Didsbury, and are a continuation of the Oxford Road lines within the City of Manchester. They are double lines, the route length being 1 mile and 122 yards. These were laid in lieu of the previously existing single line horse tramways, which had been in existence since 1881.

The new tramways are worked by electricity by the Manchester Corporation, the Council having entered into an agreement with the Corporation to lease them for a period of 21 years commencing the 1st December, 1902, at a rental of 600*l.* per mile of single tramway.

In order to provide for the double line of electric tramways it was found necessary to widen Palatine Road from 42 feet to 54 feet in width for a length of 1100 yards, and reconstruct the roadway and paths throughout. This involved the purchase of portions of the gardens of various properties along the road on the west side, the setting back and rebuilding of the whole of the boundary walls, and the replanting of gardens and shrubberies, the total cost amounting to about 17,000*l.*

The permanent way consists of girder rails weighing 102 lb. per lineal yard, laid on Portland cement concrete, this being 18 inches wide and 9 inches deep under each rail.

The paving is of Welsh granite setts 6 inches deep, the joints being racked with gravel and grouted with pitch composition.

The work was carried out by the Manchester Corporation Tramways Department acting as contractors for the Withington Council.

The cost per mile of single line was 5620*l.*

In addition to the tramways already constructed, the Council has obtained powers under the Withington District Tramways Provisional Order, 1887, for the construction of further tramways in various parts of the district. These powers have again been supplemented by further powers obtained under the Withington Urban District Council Act of 1900, and careful consideration has been given to the question of the extension of the present tramways, so as to provide the necessary facilities for the travelling public without interfering with the residential character of the district. The total length of tramways for which powers have been obtained is 15 miles 5 furlongs, in addition to those laid.

ELECTRIC SUPPLY.

The Council have obtained a provisional order, confirmed by Parliament, for the supply of electricity for public and private purposes within the district, and have transferred the same to the Manchester Corporation for a period of 13 years, the Corporation undertaking to supply electricity to ordinary consumers on the same terms as it is supplied to ordinary consumers in the city.

GAS AND WATER.

The gas supply for the greater portion of the district is obtained from the Manchester Corporation at a charge of 2*s*. 9*d*. per 1000 cubic feet; no meter rent is charged.

The portion of Chorlton-cum-Hardy, west of Barlow Moor Road from a point where that road joins Manchester Road to the junction of Beech and Barlow Moor Roads, is supplied by the Stretford Gas Company at a charge of 2*s*. 4*d*. per 1000 cubic feet, and 6*d*. per quarter meter rent.

The water supply is obtained from the Manchester Corporation, and the charges are as follows:

Domestic Dwellings:—1*s*. in the £ per annum on the annual rack rent or value. No cottage is charged less than 8*s*. per annum. Weekly property is charged to the owner, who is allowed a "composition" of 20 per cent. if paid on or before the 31st of August.

In cases where groups of houses are supplied by one service pipe from the main, the water rental is charged to the owner of the property whether weekly or quarterly.

The charges for trading purposes are the same as in the city but are payable annually.

ALLOTMENTS.

Five plots of ground have been acquired on lease by the Council in various parts of their district for allotment holders, amounting in the aggregate to 16 acres. These plots of ground are divided into allotments having an area of 200 superficial yards each, for which an annual rental of 6*s.* is charged. Each allotment ground is managed by a body of managers including members of the Urban District Council, varying from 3 to 5 in number, with a secretary who receives a small salary.

FIRE SERVICES.

The Council has from time to time considered the establishment of a Fire Brigade, having heretofore relied upon the Manchester Corporation Fire Brigade, the Corporation being paid a considerable annual sum as a subsidy for their services. This has been increased from 400*l.* in 1903 to 990*l.* per annum at the present time. As the existence of the district as a separate authority is about to be terminated by amalgamation with Manchester, a separate brigade will not of course now be necessary.

RECREATION GROUNDS.

In 1895 and 1896, the Council acquired from Earl Egerton of Tatton and Broome's Trustees, six plots of ground having a total area of 17¼ acres, which were laid out as playgrounds for children, fenced and provided with shelters, swings, etc., at a total cost of 4113*l.* exclusive of the cost of the land. These grounds are plain in character, but answer the purpose exceedingly well, and are much appreciated.

In addition to the above recreation grounds a plot of ground, 5 acres, in Palatine Road, Didsbury, was generously given and laid out as public pleasure grounds by Mrs. Josephine Helena Silkenstadt, of West Didsbury, as a memorial of her deceased daughter, after whom it is named "The Marie Louise Gardens." These gardens were very tastefully laid out and provided with shelters, and a caretaker's house with conveniences, to the designs of Mr. Joshua Cartwright, F.G.S., M.Inst.C.E., of Bury, the whole of the work being carried out at the expense of the donor and formally handed over to the Council by her in June 1903.

The site is a very fine one, and the gardens are much esteemed by the residents in the vicinity.

At each of the above recreation grounds one man acts as caretaker, excepting at the Marie Louise Gardens, where two men are employed.

BAGULEY SANATORIUM.

In 1898, it became necessary for the Council to make some provision for a hospital for infectious diseases, owing to their having received notice from the Manchester Corporation that infectious cases from this district could no longer be treated at the Monsall hospital of the Corporation, and the Council therefore purchased an estate of 38½ acres at Baguley in Cheshire, about 4½ miles from the town hall, Withington, at a cost of 5500*l*. Plans for the buildings were prepared by Mr. J. B. Broadbent, F.R.I.B.A., of Manchester, for a hospital of 100 beds, and these were duly erected and furnished complete at a cost of about 54,000*l*.

The hospital, which has been styled the "Baguley Sanatorium," was publicly opened on October 4, 1902, by the Right Honourable the Earl of Derby, K.G., the Lord Lieutenant of the County of Lancaster. Twelve acres of the land are enclosed for hospital purposes. There are five separate blocks of buildings, providing accommodation for fifty-six scarlet fever patients, thirty-six diphtheria and enteric fever patients, with eight isolation beds. There is also an administration block, in which the resident medical staff, matron superintendent, with twenty-five nurses, and the necessary staff of domestic servants are located. There is also a kitchen block, containing storerooms and a dispensary.

The water supply is from the mains of the North Cheshire Company. The lighting of the buildings throughout is by electricity, generated on the premises. The average daily number of patients is about forty-five.

The Council has entered into arrangements with several adjoining authorities for the treatment of patients, from their respective districts, at this hospital.

Soon after the opening of the hospital difficulties were experienced in the treatment of the sewage from the sanatorium, and the Author was instructed to prepare plans for sewage works on the septic tank and double contact bacterial system, followed by filtration through land.

These works have been carried out at a cost of about 800*l.*, and are now successfully in operation.

SMALLPOX HOSPITAL, NEWALL GREEN.

After a lengthy search and negotiations for a suitable site for the establishment of a smallpox hospital, the Withington Urban District Council on May 5, 1902, purchased land at Higher Baguley, called "Newall Green," containing an area of 25 acres 2 roods and 34 perches, the purchase money being 1550*l.* After considerable negotiations between the Urban District Councils of Moss Side, Withington and Levenshulme, and the Bucklow Joint Hospital Board, with a view of forming a joint committee for the purpose of maintaining a smallpox hospital, the Levenshulme District Council and the Bucklow Joint Hospital Board withdrew from the negotiations, and a committee was constituted under an agreement dated November 17, 1902, consisting of the two authorities of Withington and Moss Side. The chairman for the time being of the Baguley Sanatorium of the Withington Council is the chairman of the joint committee, and the clerk of the Withington Council for the time being is the clerk of the joint committee, and Dr. Railton, the medical officer of the Withington Council, is the medical officer of the joint committee.

On May 7, 1902, the land was let to a farmer on a yearly tenancy at a rental of 1*l.* 6*s.* per statute acre, subject to certain conditions, particularly a reservation that if the Council required the land, the tenant should forthwith give up the same on reasonable compensation being paid.

In December 1902, the Committee entered into a contract with Messrs. Humphreys, of Knightsbridge, London, for the erection of a galvanized iron hospital for twelve beds with administration block, and subsequently it was found necessary to provide a wash-house and mortuary block.

The hospital was just completed in time to receive the first case of smallpox, which came from Moss Side on February 16, 1903; altogether there were seven cases from Moss Side.

The last of the Moss Side patients was discharged on June 13, 1903, and it was followed by the first case from Withington, which was taken to the hospital on the same day. There were altogether fourteen cases from the Withington district, and the last was discharged on September 28, 1903. Altogether the hospital was open from February 16 to September 28, 1903.

The Withington Council let part of the land, namely Lot 2, containing 7 acres 2 roods and 2 perches, to the Bucklow Joint Hospital Board for hospital purposes, on a lease for ten years at a rental of 50*l.* per annum. The lease is dated January 14, 1903.

TOTAL EXPENDITURE INCURRED.

—		Payable by Moss Side.	Payable by Withington.
	£ s. d.	£ s. d.	£ s. d.
Cost of land including redemption of land tax, bank interest—less rents received	1,652 8 10		
Building and furnishing hospital	1,258 15 7		
Cost of roadway (half cost), half payable by Bucklow Hospital Board	43 17 11		
Establishment charges to February 1904	239 0 11		
Divided according to population	£3,194 3 3	1,409 13 5	1,784 9 9
Maintenance of patients, full cost payable by each		353 7 6	350 18 7
Cost of closing, half payable by each		13 0 0	13 0 0
		£1,776 0 11	£2,148 8 4

MAIN SEWERAGE AND OUTFALL WORKS.

In the summer of 1895, the attention of the Council was directed to the surcharging of the main outfall sewers, and the consequent flooding of cellars in various parts of the district, and the Author was instructed to consider the matter, and at the same time to give attention to, and report upon, the condition of matters at the sewage farm, where difficulty was being experienced in dealing satisfactorily with the increasing volume of sewage.

In January 1896, the Author presented a report, pointing out therein the total inadequacy of the outfall sewers for combined sewage and storm water, and at the meeting of the Council held in August 1896, he was instructed to prepare plans, sections, and estimates for new outfall sewers and outfall works.

These plans and estimates were laid before the Council in August 1897, and a statement thereon was made by the chairman, Mr. Councillor Swarbrick, M.Inst.C.E., at the main drainage meeting, held in the September following.

The plans and estimates provided for two detritus tanks, with a series of five precipitating tanks of equal capacity, each to contain 300,000 gallons or a total quantity of 1,500,000 gallons, or about 0·66 of the daily volume of 2,250,000 gallons, dry weather flow. The scheme also provided for new outfall sewers from near the Town Hall to the sewage works and from Whalley Range. The total estimated cost was 51,137*l*.

The Council, after considering the scheme, decided, on the recommendation of Mr. Councillor Swarbrick, that it should be submitted to Mr. James Mansergh, Past President of the Institute of Civil Engineers, for his thorough investigation and advice.

The scheme was therefore submitted to Mr. Mansergh, and several conferences between him, the chairman of the committee, and the Author took place.

Mr. Mansergh submitted his report on October 21, 1898, and his principal suggestions were—

1st. That the scheme for treatment by precipitation should be abandoned, and a scheme for double contact bacterial system substituted therefor.

2nd. That the proposed new outfall sewer (5 feet in diameter) be increased to 6 feet 9 inches diameter, and the gradient slightly amended.

3rd. That certain sewers, reported by the Author as being leaky, should be replaced by new and watertight ones.

The result of these suggestions was, of course, to greatly increase the Author's estimates of 51,137*l*., and, in fact, Mr. Mansergh's rough estimates amounted to 91,000*l*. for a population of 50,000, and to 108,250*l*. if 80,000 population were provided for.

In February 1899, the Author submitted a further report on the whole matter, comparing and revising the estimates, and proposing a modification of the proposed line of new outfall sewer from Withington.

In June 1899, a special meeting of the Main Drainage Committee adopted the scheme of the Author (subject to the modifications suggested by Mr. Mansergh), and he was instructed to prepare amended plans and estimates.

In September 1899, summonses were served on the Council, on the information of the Mersey and Irwell Joint Committee, for offences contrary to the provisions of Section 3, Part 2, of the Mersey and Irwell Joint Committee Act, 1892.

In the same month, the Author submitted his revised plans and estimates of cost of the new sewers and sewage works, amounting to 86,455*l.*, and they were approved, and application for the necessary loans ordered.

The Local Government Board inquiry into the proposed loans was held on November 15, 1899, by H. H. Law, Esq., M.Inst.C.E., and later, interviews took place between the Local Government Board and the chairman of the Main Drainage Committee and the Author, and in consequence of the requirements of the Local Government Board, the estimates were again revised and increased to 133,615*l.* in June 1900.

Sanction to the loan was given on July 14, 1900, and contracts were let to James Byrom, of Bury, for Sections 1 and 2 (outfall works), and to Messrs. J. D. Nowell and Sons for Contracts 3 and 4 (main outfall sewers).

These contracts are all now completed, and the works are in operation.

The preceding paper by Councillor Joseph Swarbrick, M.Inst.C.E., and the short history above given, will have shown the difficulties, physical and otherwise, which have existed for many years, in fact, since the constitution of the authority, in the conveyance and disposal of the sewage of the district, including that of Levenshulme, which was by an agreement in 1878 added thereto.

As described at the commencement of this paper, the district is somewhat flat in character, there being an average gradient in the direction of north to south of 50 feet. The Author found it necessary, in order to carry out the scheme of double-contact bacterial beds, to raise the sewage to 78·00 O.D. at the outfall works, and in order to avoid pumping the whole, arranged the new outfall main sewers to gravitate the sewage of the upper zone of the district and the whole of the Levenshulme sewage, leaving that from Didsbury and Chorlton-cum-Hardy only to be pumped.

The sewage farm at Chorlton-cum-Hardy is at the extreme western corner of the district, and is bounded by the river Mersey on two sides, south and west, the Chorlton Brook on the north, and an embankment on the east.

The average level of the surface of the farm, as completed in 1884, was 71·75 above O.D.; this was practically level throughout, the variation being within 1 foot either way from the above altitude.

Moreover, the river Mersey rises at flood times to about 81·00 above O.D., or to a height of 9·25 above the surface of the land.

The difficulties attending the construction of a sewage outfall works under these circumstances may be imagined.

The alternative was, of course, to pump the whole of the sewage, and a large portion of the storm-water, upon a suitable site; but owing to the proximity of centres of population, and the fact that all available sites along the river have been already appropriated for the purposes of sewage treatment by other authorities, the Author considered it impossible to suggest any other site than that already used by the Council as a sewage farm.

MAIN SEWERS.

The works recently completed consist of a main outfall sewer, commencing at point D on the accompanying map, 5 feet in diameter, in two rings of brickwork, constructed with blue brick invert, one-third of internal circumference, the remainder of inner ring being of pressed engineering bricks, the outer ring of common wire cut brickwork, all set in Portland cement mortar (1 part cement to 2 parts of sand).

The sewer has a gradient of 1 in 1380 to point O, near Hough End Hall, whence it increases to 6 feet diameter (on the junction of the northern branch sewer, which is 3 feet 6 inches diameter to point E), to point N in Barlow Moor Road. This 6 feet diameter sewer has a gradient of 1 in 1380, and is in three rings of brickwork, the invert being in blue brick, and the remainder of inner ring in pressed engineering bricks, with two outer rings in common wire cut bricks, all set in Portland cement mortar.

From point N to the sewage works, the sewer is 6 feet 9 inches diameter, constructed as described in the case of the 6-feet diameter sewer. The gradient of the 6-feet 9-inch sewer is 1 in 2192.

The latter portion of this sewer, being across low-lying land adjoining the river Mersey, is in concrete aqueduct for a length of about 683 yards.

The aqueduct is lined with brickwork in cement in a single ring, the lower third being of blue brick, and the remainder of pressed engineering bricks, all set in Portland cement.

The concrete in the aqueduct consists of one part Portland cement, two parts sand, and three parts broken stone and brick.

The whole was put into position from a striding gantry running on rails, the mixing platform being on the top thereof.

The section of the aqueduct is shown on Drawing No. 3, Figs. 1 and 2.

At point J on the map is the storm-water overflow into the river Mersey, for the discharge of all above six times the dry-weather flow. This consists of a sill placed at the side of the sewer, 22 feet in length and 2 feet above the invert of the sewer. In order to prevent exceptionally high floods in the river from backing over the sill into the sewer, a wooden-balanced flap is provided. The invert of the outfall sewer at this point is 78·61.

From the storm overflow to the detritus tanks the sewer consists of an open conduit of semicircular section in concrete, running along the top of the eastern embankment of the sewage works.

At a distance of 90 yards from the storm overflow into the Mersey, at point J, is a second overflow for the discharge of all between three times and six times the dry-weather flow into the channel leading to the storm-water filters, there to be treated as required by the Local Government Board.

From this point the sewage, up to a volume of three times dry-weather flow, is passed forward to the works for full treatment.

The construction of the above sewers excepting the aqueduct, involved no special features, being through an even stratum of gravel on boulder clay, except as to the length of 5 feet

BAN

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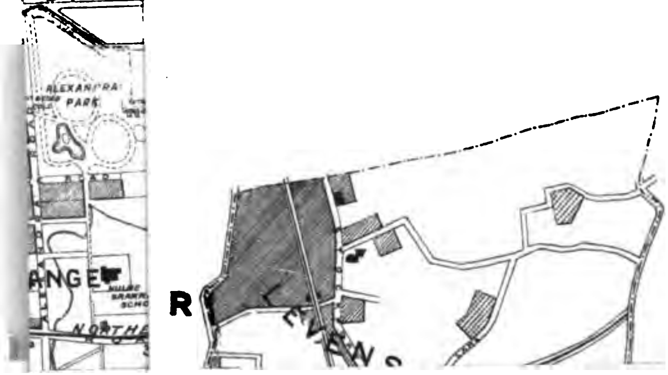
U. D.

PLATE NO. 1.



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J. EVERETT & SONS. 19, BARTLETTS' BUILDINGS, HOLBORN CIRCUS E.C.

diameter sewer in Burton Road, where the full volume of the sewage of the upper zone from Withington and Levenshulme had to be contended with. In order to cope with this, a temporary pumping station was established at the end of Nell Lane. At the crossing of the 3 feet 6 inches diameter sewer under the Chorlton Brook an inverted syphon became necessary. This is 38 feet in length and 3 feet 6 inches diameter, as shown on Drawing No. 4.

The crossings of the same sewer under the Midland Railway and the Great Central Railway also involved special work, the sewers being encased in Portland cement concrete at least 12 inches in thickness.

The velocities and discharges in the respective sewers when running full are as follows, by Ganguillet and Kutter's formula.

Diameter.	Gradient.	Velocity in feet per second.	Discharge. Cubic feet per second.
5 feet	1 in 1400	3·61	70·89
6 feet	1 in 1400	4·08	115·3
6 feet 9 inches	1 in 2192	3·5	138·2
3 feet 6 inches	1 in 1200	3·06	29·46

The main outfall sewer 5 feet diameter at point D on map is, therefore, capable of discharging, when running half full, 35·44 cubic feet per second or 797,250 gallons per hour.

The Author estimated the impervious area in the district drained by the new gravitating outfall sewer from Withington, etc., in 1897, to be 84¼ acres, from which, taking a rainfall of half an inch in the hour (of which one quarter from roads and three-quarters from roofs is delivered direct into the sewers), we have a volume of 409,860 gallons per hour which, with the sewage flow, is estimated at a total of 434,160 gallons per hour.

Allowing, therefore, for future development of the district, an ample margin of capacity in the sewer has been provided.

Had a suitable storm outfall been possible in the higher reach of the outfall sewer, the diameter might have been reduced, but this was impossible, owing to the physical character of the district.

SEWAGE OUTFALL WORKS.

The Author estimates the population draining to the works at the present time at 54,500, there being 40,000 in the Withington district, and 14,500 in Levenshulme, and the present dry-weather sewage flow at 3,000,000 or 57·7 gallons per head per day. Of this volume, probably, 50 per cent. is subsoil water which passes into the older defective sewers and drains.

About half the above volume is delivered by the high-level sewer at the outfall works at 78·0 above O.D., and the remainder, from the low-level sewers which deliver at 71·0 above O.D. into the pump sump at the sewage works, is lifted into the high-level channel adjoining the engine house by centrifugal pumps.

The steam raising plant consists of two Lancashire boilers, each 27 feet by 7 feet 6 inches diameter with two 3 feet diameter flues, having a Meldrum simplex destructor furnace 11 feet 6 inches by 6 feet 2 inches with two feeding doors, each 3 feet by 1 foot 9 inches, with combustion chamber 11 feet 6 inches by 2 feet 6 inches by 7 feet 6 inches deep.

Each unit is capable of consuming 20 to 26 tons of ashpit refuse per 24 hours, and of providing the steam for the whole of the works, and they are worked alternately, the change over being at intervals of about a month, to permit of the necessary cleaning of flues, etc.

The boilers are of Siemens Martin steel $\frac{11}{16}$-inch thick, in six rings, each of one plate. Hopkinson's fittings throughout are provided to the boilers.

The evaporative capacity of each boiler is from 250 to 500 gallons per hour, according to the quality of the refuse.

The following steam test may be of interest:—

URBAN DISTRICT COUNCIL OF WITHINGTON.

Test of Refuse Destructor Plant at Sewage Pumping Station.
Date of Test, January 9, 1904.

Type of Plant.

Meldrum's Patent Hand-fed Simplex Regenerative Refuse Destructor.

Number of cells, area 50 square feet	Two
Type of boiler, 27 feet by 7 feet 6 inches	Lancashire
Heating surface	880·2 square feet
Duration of test	8 hours
Time of test	From 9.45 a.m. to 5.45 p.m.

Class of Refuse.

Household and garden refuse.

Total refuse destroyed, including pots, tins, etc.	23,716 lb.
Weight of tins, pots, etc.	784 lb.
Weight of refuse per hour, deducting tins, pots, etc.	2866·5 lb.
Weight of refuse consumed per square foot of grate per hour	57·32 lb.
Number of times clinkered (each grate)	7
Time taken to clinker each grate	5·2 min.
Residual clinker	5264 lb.
Proportion of clinker by weight	22·2 per cent.
Normal allowance for ashpit, combustion chamber, and flue dust	8·8 per cent.
Total incombustible residue	31·0 per cent.
Ashpit pressure	1·99 inch

Water.

Total water evaporation during test	26,475·507 lb.
„ „ „ per hour	3309·438 lb.
„ „ „ per square foot of heating surface per hour	3·76 lb.
„ „ „ per lb. of refuse, actual	1·11 „
„ „ „ from and at 212°	1·26 „
Chimney pull at base	0·6 in.

Gas Analysis.

CO_2, average	13·36 per cent.
O „	6·1 per cent.
CO „	0·37 per cent.

Combustion chamber, temperature maintained throughout, at least	1900° F.
Boiler downtake	1124·09° F.
Side flue to regenerator	725° F.
Guaranteed capacity of furnace, tons per day of 24 hours—23 tons exceeded by	30 per cent.
Guaranteed evaporation of boiler, lb. per hour—3750 lb. exceeded by	11 per cent.
Feed-water temperature from heater 135°, allowing 10° F. loss between heater and boiler	125° F.
Moisture in refuse not taken.	
Steam pressure	123·09 lb.

The pumping plant consists of four Archer engines and direct driven centrifugal pumps supplied by Messrs. Tangye, of Birmingham.

No. 1 engine is vertical compound, having cylinders 7 inches and 12 inches in diameter, with a stroke 9 inches, developing 68 I.H.P. at 160 lb. pressure, and driving a centrifugal pump, having 19 inches suction and delivery pipes, and capable of discharging 6600 gallons per minute with 18 feet lift.

No. 2 engine is vertical compound, having cylinders 6 inches and 10 inches diameter, with a stroke of 7 inches, developing 33 I.H.P. at 160 lb. pressure, and driving a centrifugal pump, having 15-inch diameter suction and delivery pipes, and capable of discharging 3200 gallons per minute with 18 feet lift.

Numbers 3 and 4 are each simple vertical engines, having cylinders 6½ inches diameter, with 7-inch stroke, developing 16 I.H.P. at 160 lb. pressure, driving a centrifugal pump, having 10 inches diameter suction and delivery pipes, and capable of discharging 1400 gallons per minute with 20 feet lift.

Each pump is provided with steam exhaust and charging apparatus to suction tube and dix chamber.

The above mentioned plant is necessary in order to cope with the varying flow of the sewage, and permits of the same being dealt with, as it arrives at the works.

The pumping sump is under the floor of the engine house, and is 21 feet by 27 feet 6 inches, and the bottom thereof is at 60·0 above O.D.

This sump receives the sewage from the lower portions of the district at Chorlton-cum-Hardy and Didsbury by the old sewers, 24 inches and 27 inches diameter, from the respective districts.

The sludge-pressing plant consists of two air compressors mounted as one of the high pressure double tandem type by S. H. Johnson and Co., Stratford, London, compressing to 100 lb. per inch; and two sludge presses, each having forty-two plates 36 inches by 36 inches, and capable of pressing 8 tons of wet sludge at each charge, producing 30 cwt. of pressed cake.

The plant also includes the necessary sludge rams for receiving and raising the wet sludge from the sludge tank adjoining to the presses by compressed air, and pneumatic lime mixer 48 inches diameter by 5 feet deep.

The sewage on arrival at the outfall works is delivered into detritus tanks, of which there are two, each having a capacity of 41,704 gallons. In these tanks is deposited the heavy grit and coarser particles held in suspension by the sewage.

From these detritus tanks the sewage passes forward into two sedimentation tanks, where further deposition of the finer solid matters takes place.

On its way to these tanks the sewage passes over blocks of aluminoferric placed in the channel, and the sedimentation is thereby materially assisted.

The sedimentation tanks have capacities of 377,325 gallons and 403,650 gallons respectively.

From the sedimentation tanks the sewage passes to the first contact bacterial beds along concrete channels 7 feet wide.

The detritus and sedimentation tanks are each provided with floating arms 12 inches diameter, communicating with a conduit leading to the pumping sump, so that the top water may be taken off whenever it becomes necessary to convey the sludge from any one of them. Each tank is also provided at its western and deepest part with a valve, communicating with an open channel leading to the sludge tank, which adjoins the western end of the buildings, whence the sludge is lifted into the rams and presses.

The sewage after leaving the sedimentation tanks proceeds to the chamber containing the automatic distributing apparatus, which was constructed by Messrs. Mather and Platt, of Manchester, and is on the system known as "Ridgeway's Patent." The apparatus consists of 10 flap valves, each 3 feet wide by 2 feet deep in the opening, worked by cam "wipers" on two shafts, which are coupled by a connecting rod.

The shafts are worked by a float in an adjoining chamber, which float chamber receives, by an adjustable weir and at the rate of sewage flow, a quantity sufficient to raise the float to its maximum height, this corresponding with the completion of the filling of one first contact bacterial bed. Immediately upon this taking place, a supplementary valve comes into operation which causes the float chamber to empty, the float to fall to its lower position, and by a pawl and ratchet on the cam shaft to release the valve of the filled first contact bed, and to open the valve of the next in series.

This operation is repeated each time a contact bed is filled.

The first contact beds are ten in number, each having an area of 2900 superficial yards.

The beds are constructed with walls of blue brick set in Portland cement mortar, coped with blue copings, and have floors of Portland cement concrete 12 inches thick.

The beds are filled with screened clinkers and cinders from ¼ inch to 2 inches in gauge to a depth of 3 feet.

The sewage is conveyed by open channels and 27 inches diameter pipes from the valves in distributing chamber to the centre of each contact bed, where the sewage overflows at a little above the surface level of the bed, and is fed over the surface thereof by eight socketed earthenware carriers 12 inches wide by 6 inches deep, radiating to the extremities of the bed. This arrangement causes a very even distribution, and is found to work very satisfactorily.

Each bed is provided with half-pipe, red earthenware butt-jointed tiles, 9 inches diameter, laid on the floors of the bed and covered with coarse clinkers, in order to permit the effluent to be freely drawn off when the bed is emptying.

These drains communicate with a semicircular chamber at each outlet valve.

The sewage is held in contact about two hours, and is then passed by Ridgeway balanced valves to the second contact beds.

These balanced valves are of the same sized opening, 3 feet by 2 feet, as the valves in distributing chamber above described, but are worked by a balancing drum which is filled, by means of a flexible pipe coupling, direct from the first contact beds.

A timing cock permits the drum to fill at any desired rate. As soon as the drum is filled to the necessary extent it falls, opening the valve and permitting the contents of the contact bed to discharge, from the first contact bed to the corresponding second contact bed, or from the second contact bed into the effluent channel, as the case may be, the system being alike in each case.

The second contact beds are also ten in number, and of the same area, depth, and construction as the first contact beds.

Eight of each are worked in series, two of each being in reserve and resting.

By changing the "wiper" on the shafts at the distributing chamber any desired first contact bed, with its corresponding second contact bed, may be cut out or brought into operation, and this may be done in any order that may be desired.

The Author is pleased to say that the results from the treatment of the sewage since the beds have been fully in operation is most satisfactory to the Mersey and Irwell Joint Committee and to the Council, the latest published results, on July 14 last, of analysis made by the official analyst of the committee placing the effluent first on the list of those in the Mersey and Irwell watershed.

With the river Mersey and Chorlton Brook at ordinary level the effluent is passed into the latter, adjoining the sewage works, but when the river and brook are in flood it is passed by the old effluent channel, 30 inches diameter, into the Ousel Brook at a point near the Stretford Cemetery, and about half a mile below the sewage works.

In addition to the works above described, a scheme for a new outfall sewer for Chorlton-cum-Hardy, with storm-water storage reservoir, is in course of construction.

The district mentioned has a population of about 14,000, and is increasing at a greater rate than other parts of the Council's area. The existing outfall sewer, being only 18 inches diameter, with a fall of 1 in 800, is totally inadequate, especially when it is borne in mind that a separate system is impossible.

Flooding of cellars has for years been complained of, and general inconvenience experienced.

The Author was, therefore, instructed to prepare a scheme for dealing with the matter, and the necessary loan for same having been approved by the Local Government Board, the works are now in hand.

They consist of a storage reservoir about 9 acres in area, with a pumping station adjoining the storm overflow into the river Mersey at point J on the map.

The reservoir is rendered necessary by the rising of the river Mersey in flood time above the level of the land adjoining the sewage works, as previously described.

Heretofore, the outfall sewer from Chorlton and Whalley Range was furnished with a storm overflow into the Chorlton Brook at a point about 500 yards east of the sewage works, but whenever the river Mersey and Chorlton Brook were in flood this storm overflow became inoperative, and the outfall sewer became blocked until the river and brook fell to their normal level.

A new sewer is, therefore, in course of construction from the storm-water reservoir at point P on map to point H, this being 6 feet 6 inches in diameter at the reservoir, diminishing to 4 feet 6 inches from point H to K.

In this sewer, and adjoining the south side of the Chorlton Brook, will be a weir, diverting the ordinary sewage flow into the existing 2 feet diameter sewer to the sewage works, the excess storm-water passing forward to the reservoir, whence it will be passed by gravitation into the river Mersey when not in flood, and by pumping when the level of the river is above the water level in the reservoir.

The present connection by storm overflow with the Chorlton Brook will be discontinued on the completion of the new works.

The pumping plant proposed will consist of centrifugal pumps, driven by oil engines, and will be capable of lifting 7000 gallons per minute, with a lift of 18 feet.

The soil at the sewage works consisting of alluvial deposit, considerable difficulty was experienced in constructing the foundations of the boiler and engine house, and chimney shaft, and piling had to be resorted to.

The piles are driven in pairs, at distances apart of 4 feet, through the blue alluvial clay into the underlying red sandstone rock, which was met with at about 43·24 above O.D. or 29 feet below the original surface. The piles were 11 inches and 12 inches square, and were driven to the solid in every case.

Upon the heads of the piles, which were sawn off to a regular level, concrete 3 feet in depth by a width of 4 feet was filled, and the brick footings laid thereon.

The Author considers the satisfactory inception and completion of these works to be due chiefly to the enlightened policy of the Withington Council in realising the necessity for the expenditure, and in their not hampering the Author by unduly "cutting down" the scheme, which is far too often the case with local authorities.

The Author also wishes to acknowledge the invaluable services rendered to the Council and himself by the chairman of the main drainage committee, Councillor Joseph Swarbrick, C.E., by the chairman of the main drainage works committee, Councillor W. Norquoy, and the members of these committees, in the careful consideration of the multitudinous details which have so long been before them, and for their very practical advice and suggestions on many occasions.

The Author is also deeply conscious of the ability and untiring energy and care exercised throughout the execution of the works by the resident engineer, Mr. G. M. Collins, and the staff of inspectors under him.

DISCUSSION.

Mr. J. **Patten Barber**: I beg to propose a sincere vote of thanks to the Authors of the papers. I can remember this place when it was little more than a village, and the only educational provision for rich and poor was the national school. I know some of the difficulties with which the urban district council have had to contend, and I am quite certain that the way in which their engineers have surmounted those difficulties is a credit to the profession to which we belong. I have, therefore, peculiar pleasure in moving that a vote of thanks be given to Mr. Mountain and Mr. Swarbrick for their papers on the work carried out in this important district.

Mr. S. S. **Platt**: I have very great pleasure in seconding the vote of thanks which has been so ably proposed by Mr. Barber. I think we are exceedingly fortunate in having the two papers, giving, as they do, a consecutive history of sewage disposal in Withington for a good number of years. It has been my fortune to know something of the earlier works of Withington, the sewage works particularly, when Mr. Swarbrick was the engineer, and I knew the difficulties he had to contend with. I knew the farm when it was acting satisfactorily, and when it was not acting satisfactorily. It is one of those cases of a farm where the committee unfortunately interfered with the engineer's arrangements. They were troubled with a great volume of sewage, and instead of facing the difficulty properly, the Committee introduced some intervening shallow drains, which certainly clarified a large volume of sewage but did not purify it. The historical part of the paper does not call for much comment. It is a very good account. When we come to Mr. Mountain's paper, we are under the disadvantage of not having yet seen the works. They have adopted contact beds, due largely to the difficulty of levels. Further than that, when the question had to be faced, the contact system appeared to be the only one possible. Since then, other types of bacterial treatment, such as sprinklers, have come into favour, and there is, just now, a tendency to abandon contact beds and go in for sprinkler beds. I can say, from my experience of both, that the sprinkler beds have come to stay, of course, that is, where the levels will allow it. The beds are less likely to choke up than contact beds, as you get continuous aëration. They have also the old farm to fall back upon as an adjunct to the contact beds, so they can, if necessary, pass the effluent over the land. I can, however, say, from an experience of an alluvial soil like that at Withington, that they will have to give the land a satisfactory rest before they can expect to get a good effluent from it. To put an effluent from contact beds on land not qualified to improve it would be a mistake.

Mr. A. M. **Fowler**: The bacteriological system cannot be applied universally to all places for the treatment of sewage. Wherever this system is adopted, you must first clarify the sewage and free it from mineral matter by detritus tanks and sedimentation before passing it on to the bacteria beds. With a domestic sewage you can then get a very good effluent, an effluent in which the albuminoid ammonia is not greater than say 0·1 grain. An effluent of that character is admissible into any stream. But in the working of bacteria schemes, as time goes on, the beds lose their capacity. Therefore, when you come to deal with a manufacturing town, where manufacturing refuse is turned into the sewers, there is sometimes difficulty in providing for screening to prevent the fibrous and other waste material going into the beds and thus choking them up. For this reason I should like to caution all municipal bodies against forming too hasty conclusions as to the system of sewage disposal to be adopted. There is a very wide difference between the treatment of domestic sewage and the treatment of the sewage of manufacturing towns, and I challenge the profession to say that the bacteria system will treat every class of sewage. Perhaps it is a happy circumstance for us as engineers that the sewage of each town must be treated from its own standpoint.

Dr. **Fowler**: I rise with some diffidence as being a visitor in your midst, and also a Member of another profession—a profession which, I hope, will always work hand in hand with Municipal Engineers in the solution of the problems with which these papers deal. I think if we are to solve the sewage problem in all its varying manifestations, the united work of the engineer and the chemist is necessary to obtain success. Fortunate it may be for all of us that it is so. With regard to the works we are going to see, I again have some hesitation in speaking, as I may have something to do in looking after them in future. I will only say this, that one can rarely enter upon new work with the same confidence and pleasure that one does with works of this sort. Everything has been done to make them as good as they could possibly be, and I am looking forward to getting very interesting and good results from them. At any rate, if anything goes wrong in the future, no one can say the engineers are to blame. There are a number of points of general interest which one could discuss—there is the perennial one of contact beds against continuous filters. I think you will find you can get equally good results from both if you have sufficient space in each case. You have to decide by the area available which plan to adopt. If you have a sufficient area, I think it is economical to go in for contact beds. On the other hand, where you are shut in a corner and obliged to pump, I think you will find it best to go in for continuous filters. In each case you must deal with the question as best fits local conditions. As to the danger of sludging up contact beds. In the past, and to some extent in the present, it seems to be assumed by engineers that if your contact bed becomes sludged up, the thing is a failure. I would venture to say that the washing of the sand of a waterworks filter is a more expensive process than the washing of cinders from a contact bed. I have gone carefully into the methods and cost of both. The washing of a cinder bed can be done very cheaply. They are doing it at Burnley at 1*s.* per cube yard, and where that has to be done only once in five years, the cost is not very great. The elaborate arrangements for straining and otherwise clarifying your sewage will result in greater cost than the simple method of cleaning the material at long intervals. I commend this latter to the engineering profession.

Mr. J. CORBETT: These papers have been of very great interest to me, not only from the careful history of the neighbourhood and its drainage, but also because the scheme runs parallel with the scheme which we are carrying out at Salford, and which I hope to see, but cannot be sure of seeing, finished in my time. As to the question of contact or trickling beds, Withington had the choice of either, because there is a fall of 6 feet 6 inches, so it would have been possible to have had sprinklers and beds 5 feet deep. Which of the two will prove more efficient will take many years to determine. Since coming into the room, one idea has been impressed upon my mind, whether it would not be possible to have a deep drain running right through the district to the Ship Canal, and I would like to know whether the difficulty in the way is an engineering one, or that of getting three or four authorities to join together. It would be a public benefit, and a desirable thing to have. Now that Withington is being amalgamated with Manchester, things which could not be thought of in Withington may be thought of in Greater Manchester. This is a very bold scheme, with sewers of 6 feet 9 in. in diameter. For a country residential district such as this it shows the boldness with which the difficulties have been attacked, and we shall all be interested in seeing the actual way in which the work has been carried out.

The vote of thanks was unanimously accorded.

Mr. SWARBRICK, in reply, said: It is scarcely possible for me to express the delight which I personally have in seeing the Association at Withington. I wanted a meeting 20 years ago, but it did not take place. At any rate, there is a deal more to see now than there was in those times, when we were struggling against many difficulties. With regard to Mr. Corbett's question as to the deep drain, thirty years ago there were many attempts made to carry out a joint scheme, even before the Ship Canal, but everything of the kind was impossible, because we were not part of Greater Manchester and Salford. Probably when we get the two united as well as all the suburbs, we may carry out many schemes of great benefit to the several districts, which in our present condition are absolutely impossible.

Mr. A. H. MOUNTAIN, in reply, said: I am very much obliged to you for the very kind vote of thanks passed for the paper which I have had the pleasure of giving. I should like to say, in reply to Mr. A. M. Fowler, that, with reference to the clarification of the sewage, this is done by the large sedimentation tanks we put down, and as a preliminary to sedimentation we have the detritus tanks, so that it is a fairly clarified sewage that comes forward for treatment. The sewage is entirely domestic, and we have no manufactures, so the difficulties he has spoken of do not arise at Withington.

With regard to the treatment on land, it is intended, when the land has been returned to a clean condition by ploughing and working, to turn the effluent upon it, and to cultivate crops.

With regard to Mr. Corbett's remark as to the 6 feet depth required for sprinklers, our volume increases so rapidly, up to nine or ten million gallons and more at times, that I do not think sprinklers could be satisfactorily adopted. Then as to the suggested deep effluent outfall culvert to the river, we should have had to go through a number of other districts, urban and rural, and time would not permit of the negotiations, etc., necessary, and the results in any case would have been doubtful and the cost excessive. We were being forced to action by the Mersey and Irwell Joint Committee, and we adopted the then best known means of dealing with the sewage. With reference to the large size of the new sewers, many of the older sewers, laid in twenty years ago and more, were far too small, and we determined in this instance not to make any mistake of this kind, but to construct the sewers sufficiently large to allow for any future developments of the district that could be reasonably foreseen.

Communicated Discussion.

Mr. G. W. Lacey: I should like to know, if, in view of what has been saved in other towns by giving up chemical treatment of the sewage and adopting natural sedimentation and septic treatment, Mr. Mountain has arrived at the conclusion that the system he adopts is the most satisfactory for his district, and the reason for so doing, and in connection with this it would be most interesting to be supplied with a fair average analysis of the sewage and the effluent obtained by the dual treatment, chemical and bacterial. It seems to me, however, that given tanks of sufficient capacity for either adequate sedimentation or liquefaction, the bacteria beds should be able to perform the remainder of the purification, and the working expenses would be lessened by a very considerable sum, by reason of having no chemicals to provide and a less quantity of sludge to deal with.

Respecting the size of the material in the primary beds, my personal experience is against the use of material containing a considerable proportion of a gauge so small as a quarter of an inch, and I shall be glad to know if the Author has gaugings to show what loss of capacity has taken place in the primary beds which have been longest in use. The question of material, its nature and size, is one of the most important, in my opinion, in regard to primary contact beds.

The working area of each set of beds is 8 × 2900 = 23,200 square yards or nearly 5 acres, and this represents a rate of 129 gallons per square yard or approximately 600,000 gallons per acre per day, based on the dry-weather flow. Taking the water capacity at ⅓ of the total cubic capacity, this gives 2½ fillings (nearly) to each bed per day, which is sure to be increased after say two years' working. Multiply this by 3 (three times dry weather flow) and it is apparent that in wet weather the beds will be heavily taxed; but probably the beds in rest can be brought into temporary use at such times.

The Author does not describe the construction of the storm-water filters nor give their area, which information would, I think, be usefully added to the paper, and also in what manner the sludge is disposed of. Will he also state what is the cost per ton of burning the house refuse?

Communicated Reply.

Mr. A. H. Mountain: The only chemical treatment in use at Withington is the placing of a block of aluminoferric cake in the sewage channel to assist the sedimentation in the detritus and sedimentation tanks. I doubt the advisability of septic treatment as a preliminary to the double contact bacterial treatment for ordinary domestic sewage such as is treated here. In my opinion it is impossible to obtain the best results continuously without first abstracting the solids as far as possible. The aluminoferric itself of course makes no addition to the quantity of sludge. As to the size of the material, my experience for three years of the experimental beds laid down showed that exact grading of the material was unnecessary. Some diminution of capacity is to be expected, but this will be due both to the consolidation of material and the accumulation of humus on the surface of the cinders and in the bed generally.

The capacity of the eight primary beds in work is 3,902,240 gallons per day with three fillings, or 168·2 gallons per superficial yard, not 129, and if the two beds resting be brought into operation a further quantity of 975,560 gallons may be dealt with, or a total of 4,877,800 gallons. At times of heavy rain the beds will be filled more frequently, and all above 9,000,000 gallons flow will pass to the storm-water, continuous-flow, filter beds.

These are two in number and together have an area of 2½ acres. They are capable of treating, at the rate of 500 gallons per superficial yard per day, 6,050,000 gallons. They are, like the bacterial beds, 3 feet in depth.

It must be remembered that the dry-weather sewage flow is always diluted with subsoil water to the extent of 50 per cent.

The sludge is pressed in the Johnson's presses, and the cake is mixed with the dry ashpit refuse and burnt in the Simplex Destructor cells, the clinker resulting being now conveyed to the storm water filter beds to complete the filling thereof. I am not yet able to give with accuracy the cost of burning the refuse at the sewage works, but at the old destructor in Nell Lane the cost is about 8*d.* per ton.

CREMATION
IN MANCHESTER AND ELSEWHERE.

BY J. HARVEY SIMPSON,
SECRETARY OF THE MANCHESTER CREMATORIUM.

THE necessity for a more rational method of the disposal of human remains has been forced upon the community at large mainly for two reasons:—

1. The increase of towns and populous places.
2. The dangers to the public health to which places of interment give rise.

Modern cremation was first brought before the British public in an article written by the late Sir Henry Thompson, and published in the 'Contemporary Review' of January 1874.

The publication of this article resulted in the formation of the Cremation Society of England, in 1875.

Before dwelling upon the arguments in favour of cremation it may be well to venture a few remarks upon the two most prominent objections raised against it.

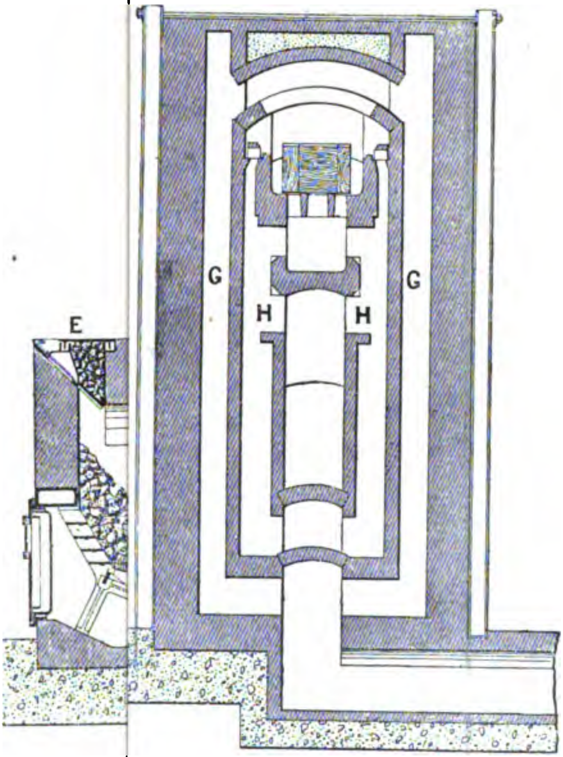
And firstly as regards the religious objection.

In 1886 His Holiness the Pope promulgated a decree in which he stated that cremation was a detestable abuse, and that it was not lawful for any Roman Catholic to leave orders for cremation.

Cardinal Vaughan, the late Archbishop of Westminster, said that cremation was the revival of a pagan system, anti-Christian, anti-Biblical; and that if the body were to be annihilated by cremation, faith in the doctrine of the Resurrection would grow weaker and weaker, and would eventually disappear.

The natural replies to these arguments are that interment is a continuation of a pagan custom, that no objection to cremation is raised in the Scriptures, and that nature recognises no such thing as annihilation—there is simply a change in the constituents of the body, and that occurs whether cremation is resorted to or

MANCHESTER CREMATORIUM.



Cross Section.

REF D, ash hopper; E, cast-iron hoppers;
cess from top of cremating chamber to
ir.

To face p. 128.

ordinary interment. Bishop Frazer, of Manchester, said, "No intelligent faith can suppose that any Christian doctrine is affected by the manner in which, or the time in which, this mortal body of ours crumbles into dust and sees corruption."

The present Bishop of Manchester lately wrote, "We shall come to see that, under the conditions of modern life, cremation is not only preferable from the sanitary point of view, but that it is also a most reverent and decent treatment of the bodies of the dead, and one that is in entire accordance with Christian belief."

The second objection raised against cremation is called the medico-legal difficulty.'

It has been argued that with the spread of cremation the number of deaths by poisoning would greatly increase. For a time it was somewhat difficult to answer this objection fully, but fortunately, in 1893, a Select Committee of the House of Commons was appointed to inquire into the sufficiency of the existing law as to the disposal of the dead, for securing an accurate record of the causes of death in all cases, and especially for detecting them where death may have been due to poison, violence or criminal neglect. The report of the committee, with the evidence taken by them, has been printed and can be purchased for 3*s.* 4*d.* It contains no less than 350 pages, and is most valuable as proving the present defects in death certification and generally in regard to the disposal of the dead. Deaths are classed as certified and uncertified; and even as regards certified deaths, the report states that, so far as affording a record of the true cause of death, and the detection of it in cases where death may have been due to violence, poison, or criminal neglect, the class of certified death leaves much to be desired. Dr. Glaister, of Glasgow, informed the committee that he saw no difficulty for anybody to perpetrate a crime, get the whole matter certified and registered, and the body interred without anyone detecting it. Time fails one to cite the numberless instances in this evidence and report, proving that the medico-legal difficulty is ever present where ordinary interment is resorted to, instead of where cremation is resorted to. Recommendations for legislation are given by the committee to remedy the present defects, but so far nothing has been done. The question now arises whether by cremation these dangers are in any way got over, and the answer is that as regards cremation the medico-legal difficulty has practically disappeared by reason of the passing of the Cremation Act, 1902, and the rules and orders in pursuance of such Act.

The following are the requirements under the Act for a cremation:—

1. The usual registrar's order for burial.

2. An application for cremation by the nearest relative or executor of the deceased, to be signed before a solicitor or justice of the peace.

3. Two medical certificates, one to be signed by the ordinary medical attendant of the deceased.

These forms are placed before the medical referee of the crematorium, whose duty it is to carefully examine the same and if satisfied to give a written authority to cremate. Each crematorium is bound, under the Cremation Act, 1902, to appoint a medical referee, and the second medical certificate is to be signed by a medical practitioner of not less than five years' standing.

The above requirements prove, therefore, that no cremation can take place except under satisfactory conditions. Having considered the two popular objections to cremation, we now turn for a few moments to the arguments in favour of cremation.

1. *The Sanitary Argument.*—In regard to a dead body, we have a duty to perform—

(*a*) To the deceased.
(*b*) To ourselves and to our descendants.

In relation to the deceased, we must see that the dead body is dealt with kindly, decently, and in a spirit of reverence.

In relation to ourselves and to our descendants, we must see that in our manner of dealing with the dead body we leave no legacy of disease and pestilence from which we and our descendants may suffer from our disregard of proper sanitary precautions.

Immediately after death decomposition sets in—the resolution of the body from its complex chemical compounds into simpler and more elementary substances.

By interment—slow decomposition, slow putrefaction.

By cremation—quickly, surely, without danger to anyone.

The dangers to the public health to which places of interment give rise are of two kinds :—

(*a*) The contamination of air by the gaseous and volatile, and
(*b*) Of drinking water by the liquid and soluble products of decomposition.

Another powerful argument in favour of cremation is—

2. *The Land Question.*—The late Bishop Frazer said: "Here is another 100 acres of land withdrawn from the food-producing area of the country for ever. I feel convinced that before long we shall have to face this problem—how to bury our dead out of our sight more practically and more seriously than we have hitherto done. In the same sense in which the Sabbath was made for man, and not man for the Sabbath, I hold that the earth was made not for the dead, but for the living."

This question forms one of the paramount problems of the day, and waits for an immediate and satisfactory solution, the only satisfactory solution being cremation. The church-yards could then be used by the erection of arcades and columbaria to contain the cremated ashes.

The following are the present crematoria in England and Scotland :—

Birmingham
Darlington
Glasgow
Hull
Leicester
Liverpool
London (Woking)
„ (Golder's Green)
„ (Ilford)
Manchester.

The crematoria at Hull and Leicester were erected from municipal funds by special Acts of Parliament; but now, under the powers contained in the Cremation Act, 1902, any municipality can vote funds for the erection and maintenance of crematoria. The crematorium at Ilford was erected for the City of London under such powers. The other crematoria were erected by private subscription, and will, it is anticipated, be eventually taken over by their respective municipal authorities.

The main architecture of a crematorium is a detail entirely to the taste of the architect. The architecture of the Manchester Crematorium is similar to churches to be found to-day in Lombardy and Venice.

As regards the furnace portion of the architecture, the form used at the Ilford Crematorium, which is an improvement upon that of the Manchester Crematorium, is the best one at present suggested.

DESCRIPTION OF AN IDEAL CREMATORIUM.

At the front is the hall or chapel. In the centre of the wall opposite to the principal entrance is placed the catafalque or aperture leading to the furnace room. A vestry or waiting-room is at the left of the hall and the furnace chimney at the right. The hall is flanked on either side by open arched colonnades raised above the level of the ground, protecting columbaria erected between each arch. There should be an organ over the front entrance and a pulpit to the right of the catafalque, the sides and front of the catafalque being decorated with palms and green plants. The centre of the hall is kept vacant for the entrance of the coffin and mourners, each side being filled with chairs standing on matting so as to add to the warmth and comfort of the mourners. The bearers bring the body along the hall and place it upon the catafalque, whereupon the funeral service commences. In the centre of the catafalque is an invisible chain. At the words of committal, an electric button is pressed, a curtain drawn, and a door opened, an operator at the back working the chain, whereupon the coffin glides noiselessly into the chamber beyond, where it remains until the conclusion of the service, the door again being closed and the curtain unfolded.

For the cremation the chain winds the coffin on to a trolley laid on transverse rails; the trolley moves either to the left or to the right exactly before the furnace to be used. By the use of these transverse rails any number of entirely independent furnaces can be in operation at the same time. There is thus the one hall or chapel at the front and the cremating chamber with furnaces at the rear, the furnaces to be increased as occasion may require.

The charges for cremation, including all fees, vary from two to five guineas; but, in considering the expense of cremation as compared with ordinary interment, it must be remembered that an expensive coffin is useless. The cost in any case should not exceed 3*l.* 10*s.*, and it is not necessary to purchase a grave or expensive monument or stone.

Engineers will, however, be mostly interested in the description of the furnace.

1. *Cremation by Electricity.*—The Author has made very careful investigation, but can find no record of any cremating furnace worked by electricity. It is to be hoped that some municipal corporation will use this method of incineration.

2. *Cremation by Fuel.*—A description of the Manchester furnace invented by Henry Simon, Ltd., Engineers, of Manchester, is as follows:—

The furnace mainly consists of the gas generator and the cremating chamber, which are both built together in one block and connected by gas and air conduits. The gas generator is a V-shaped furnace of the vertical type, built of fire-bricks and fitted with suitable fire-grating. The fuel for charging the generator is fed through two cast-iron hoppers arranged with slides on the top of the furnace.

The cremating chamber is entirely built of the best fire-clay material, and constructed in the shape of a horizontal retort, with an arched top and a perforated or grid-like bottom; both ends are provided with vertical sliding doors.

Underneath the cremating chamber there is a second chamber, in front of which is a funnel-shaped ash hopper, and at the back a sliding door. This second chamber serves for finally burning any parts of the body which may fall during the process through the perforated bottom into which the body to be cremated has been first introduced. The gas generator is charged with clean fuel, preferably pure coke, and for a few hours an ordinary fire is maintained, gradually increasing in intensity. Then hot gases thus created pass through conduits up to the cremating chamber, heating its walls increasingly. This method of firing, however, is only used in the beginning, as it would not be sufficient to produce the intense heat required in the cremating chamber, viz. 1800° to 2000° F.

The fire, therefore, is, after a time, conducted in a different way, viz. instead of ordinary complete combustion of the coke being allowed to take place, the supply of atmospheric air is reduced by closing the slides, and an imperfect combustion only allowed to take place. Instead of carbonic acid, which is the result of complete combustion, oxide of carbon only is thus engendered, which, at a point higher up in the furnace and at the sides of the upper cremating chamber, is brought into contact with pure atmospheric air entering through separate channels. The combustion of oxide of carbon by this means is taking place exactly at the point where the greatest heat is absolutely wanted, viz. around the body to be cremated. The air is thus heated before coming into contact with the oxide of carbon, and produces in this way a much higher degree of heat than could be obtained by the admission of cold air. The furnace is ready for cremation as soon as the cremating chamber glows with a bright orange colour. The body to be cremated can then be introduced. After about an hour the process is completed; and the remains are, by means of an asbestos brush, pushed into the hopper, falling hence, without being touched by human hands, into the urn which has previously been placed underneath.

3. *Cremation by Gas.*—This method of incineration is in use at the Rouen Crematorium.

The lighting gas furnace has six principal parts:—

1. Incinerating chamber.
2. Introducer.
3. Gas-burner.
4. Recuperator.
5. Flue from furnace to chimney.
6. Chimney.

The incinerating chamber and recuperator is a vault-shaped chamber of brick, with two grooves in the floor, in which the projections of the introducer slide. At the far end are the gas-burners; at the two sides are the pipes which bring the hot air from the recuperator, each provided with a regulation tap for regulating supply. Also at the sides, but nearer the front, are pipes or flues, for conducting the incineration vapours and gases to the smoke tubes of the recuperator. The front of the chamber is shut by a double door. The outer door consists of two folding doors in cast iron, opened and closed by a handle. The inner door of cast iron is a sash frame, fitted with fire-brick blocks, which slide up and down by counterpoise weights. The recuperator is constructed below the incinerating chamber. It is composed of a system of pipes, tubes and flues, so arranged that those conducting the products of combustion from the chamber warm those which introduce and conduct the cold air, thus heating the cold air before its admission to the chamber. This hot air intensifies the heat from the burners, and accelerates the whole operation of reducing the body to white ash. Several dampers enable the heat of the chamber to be regulated to a nicety, and prevent the consumption of more gas fuel than is actually necessary. The gas-burners are a series of copper candles, with Bunsen burners in the bottom, mounted on a gas chamber. The upper part of these copper candles is completed by an iron tap behind the chamber.

The introducer is a mechanical apparatus for introducing the coffin into the incinerating chamber and removing the ashes therefrom.

A pilot fire is necessary at the base of the chimney for creating a draught.

4. *Cremation by Oil.*—This method of incineration is in use at the Gardner Earl Memorial Crematorium, situate at Troy, New York State. A tank, with a capacity of 500 gallons of kerosene oil, is placed outside the building, and the oil is conducted to the retorts through pipes, a pressure of ten pounds of air making the flow constant. The oil thus forced through the pipes enters a burner placed within a chamber, 18 inches square, in the rear of each retort. Mixing with air, it forms a gas, and when burning produces an intense heat, especially when combined with the natural gases produced in the retort. Air from a tube passes over the burning oil and the gas is forced into the retort, where it is met by air coming in through three flues, each of 6 inches diameter. The burning gases pass directly over and around the body, thence under the fire-brick bed of the retort, and finally to the chimney, where a second burner, giving forth a heat nearly as intense, causes the absolute destruction of all remaining gases. The generation of this heat to an approximate temperature of 2000° Fahr. is extremely rapid. The entire process lasts two hours, and about twenty-five gallons of oil are consumed during incineration.

For further details as to cremation generally, the Cremation Act, 1902, and cremation statistics, the Members are referred to 'Cremation in Manchester and Elsewhere,' by J. Harvey Simpson.

DISCUSSION.

Mr. A. D. **Greatorex**: I have pleasure in proposing a vote of thanks to Mr. Harvey Simpson for a paper which will be a very valuable addition to our Proceedings. If at any time any of us have to report to our councils on the subject of cremation, we shall have this paper as a reference and know where to get information on the subject.

Mr. W. **Jones**: I have pleasure in seconding the vote of thanks.

Mr. A. J. **Price**: There are, no doubt, in many parts of the country water supplies which are very largely contaminated by percolations from graveyards. I was, some years ago, in a town in the south of England, part of whose water supply is drawn from wells close to a cemetery, and a town councillor described this in terms which I would not like to use in this meeting. He said bones were rotting in the graveyard, and pollution from them was getting into the wells. There is no doubt that he was altogether wrong, as the flow of the water was in the other direction and there was little or no danger of pollution. At the same time, the town had to call in experts to allay the alarm created by the speech, and were put to a good deal of expense. On practical grounds there may not be much objection to cremation, though, of course, there is the difficulty as to cases of poisoning. The chief objection is, however, a sentimental one. On sanitary grounds we are all in favour of it.

Mr. **Harvey Simpson**, in reply: First of all, I must thank the Association for their kindness in allowing me to give a paper upon this subject. The paper is very short, but I intended to offer a few practical particulars to include in your minutes and be available for reference. There are four methods of heating the furnace: electricity (which has not yet been tried, but ought to be the thing of the future), coal, gas, and oil. I should say that oil is the cheapest of the four.

The Members were entertained to luncheon, Mr. Turnbull, Chairman of the District Council, presiding.

The afternoon was devoted to visits to the crematorium, where the cremation of a body took place, the destructor and concrete-flag making works, the sewerage works, Chorlton outfall works, Baguley sanatorium, and the Marie Louise Gardens, Palatine Road.

On their return to the Town Hall the Members were entertained to tea.

YORKSHIRE DISTRICT MEETING AT CLECKHEATON.

March 18, 1905.

Held in the Council Chamber, Town Hall, Cleckheaton.

A. T. DAVIS, M. INST. C.E., PRESIDENT, *in the Chair.*

THE Chairman of the District Council (Mr. Councillor Field, J.P.) received the Members, and offered them a hearty welcome to Cleckheaton.

The President, on behalf of the Association, thanked the Chairman for the kind welcome he had given them.

The Honorary District Secretary read the Minutes of the last District Meeting at York, which were confirmed and signed.

Mr. W. H. Hopkinson was unanimously re-elected Honorary Secretary for the Yorkshire District.

The following papers were then read and discussed :—

THE MUNICIPAL WORKS OF CLECKHEATON.

BY C. LUND,

SURVEYOR TO THE URBAN DISTRICT COUNCIL.

IN its industrial aspect, Cleckheaton is probably unique. Such a diversity of manufactures can hardly be carried on in any other English town of seemingly similar importance. Cleckheaton's public enterprise is the source of its economic prosperity, and it is necessary here to lay some little stress on the existence of large and thriving textile mills and of works devoted to wire-drawing, card-clothing, chemicals, leather, and engineering, in many various branches of each trade. The rise of these industries has been contemporaneous with the growth of the factors by which we are wont to measure a municipality; and that the growth of Cleckheaton has been gradual and consistent, a few statistics will suffice to show. If the year 1861 be taken as a starting point, it will be possible to measure with some accuracy the developments that have accrued since the formation of the first Local Board in 1863.

In the first year of that decade the population was about one half and the rateable value not much more than a quarter of those now recorded. Here follow the official statistics:

Year.	Population.	Rateable Value.
1861	6,231	£16,480
1871	8,138	29,000
1881	10,653	36,828
1891	11,826	43,833
1901	12,520	53,259
1904	13,000 (estimated)	58,288

In the first forty years, it will be seen that the population doubled, while the rateable value trebled. Between 1891 and 1901, while the population increased 6 per cent., the value improved 50 per cent., and during the three years following a similar growth in material prosperity is to be observed.

With these facts in support, the local administration is completely justified in making adequate preparations for the enlarged requirements that are plainly destined to come.

The area over which the urban district council has charge covers 1755 acres, and ranges from 240 feet to 560 feet above O. D.

More than 14 miles of roads and streets traverse the district, certain lengths being subject to peculiarly heavy traffic. Some 6⅛ miles are main roads. The county council pay to the district council the whole of the actual expenditure on maintenance plus 5 per cent. for establishment charges, the average annual expenditure being 336*l*. per mile.

The other roads of the township are maintained at the rate of about 175*l*. per mile per annum.

The cost of watering averages about 60*l*. per annum.

The materials used on the roads are Leicester granite and Low Moor dross.

The tramways of the British Electric Traction Company (heavy woollen district) connect Cleckheaton with Dewsbury and with the intermediate townships of the Spen Valley. At the by-passes upon the tram route and in the narrower margins left by the rails recourse has been had to granite setts from the Ystehede quarries of Messrs. Brookes, Ltd., in Norway. The hard York non-slip artificial flags made by the same firm have been used in conjunction with natural stone for footpaths.

The town hall with municipal offices has set something of an example to those building in Cleckheaton for private purposes. It was erected at a cost of 17,000*l.* under the supervision of Messrs. Mawson and Hudson, Architects, Bradford.

Low pressure hot water affords heat, and electricity gives light throughout the premises. In addition to the large hall of 90 by 35 by 34 feet high, which accommodates comfortably 1000 people, there are a council chamber, committee room and anteroom on the first floor. On the ground floor are the offices of the officials of the council, curator's rooms, and in the basement are the plumbers' workshops and stores of the gas and water departments.

The public baths were provided in 1889 at a cost of 5,000*l.*, and were erected under the joint supervision of Messrs. R. Castle and W. Howorth, Architects, Cleckheaton; they minister to a distinct want, and they are, doubtless, worth more to the community than their direct cost. The average expenditure per annum is 350*l.*, and the receipts are some 170*l.*

The accommodation provided is as follows: one plunge-bath, 60 feet by 21 feet, from 4 feet to 7 feet deep; one plunge-bath, 30 feet by 15 feet, from 18 to 43 inches in depth; thirteen slipper baths; eight vapour baths; and first-class Turkish and Russian bath. The partitions are of pitch pine.

A singularity about the water in use at these baths is that it is pumped from old coal workings, and after filtration the water in the baths is seen to be of a beautiful transparency, and blue rather than yellow in tone. In nature the water is heavily charged with oxide of iron, from which it is freed by upward filtration through a layer of foundry dross and breeze from coking ovens.

The water is lifted by means of two Bailey's Aqua-Thrusters; some 50,000 gallons are required to fill the two swimming-baths; this is pumped and warmed at a cost of 9*s.* or one ton of coal. A Lancashire boiler, 16 feet by 5 feet 6 inches with one fire-box, raises the necessary power and is workable up to 50 lb. pressure. In ordinary practice a pressure of 10 lb. to 15 lb. of steam suffices for pumping and warming, and for the operation of the steam laundry and for bath purposes.

In the laundry are a rotary washing-machine and a wringer, by Summerscales, which are actuated by a 4 horse-power steam engine. A very efficient Broadbent's hydro-extractor is driven by direct coupling, and a drying-chamber, with sliding-horses and the necessary fittings are by Messrs. Bradford, of Manchester.

The public are allowed the use of the laundry at the rate of *4d.* per hour.

The stables and fire brigade were erected in 1890 at a cost of 3,000*l.*, and are situated in Bradford Road. Eight horses are kept, the council doing most of its work direct. The Author has been asked to inquire into the merits of motor traction for municipal work with a view to a report being drawn up and presented to the council at an early date, and he would be obliged if any of the Members present who have had experience of this subject would furnish him with their views thereon.

The fire brigade is a volunteer body under the captaincy of Mr. Edward Mitchell, and consists of one superintendent, one foreman, and twelve men. It is equipped with large and light hose-carts and collapsible ladders. A horse ambulance presented to the town in 1897 by the late Alderman Arthur Anderton is also housed here.

A hose tower crowns the fire station, where is the residence of the superintendent, as well as the public mortuary, which has been constructed as an addition by the Author. The interior walls are of white glazed bricks and the exterior of delphstone.

Water is arranged for by purchase in bulk from the adjacent city of Bradford.

A sum of 17,000*l.* raised to purchase distributing plant has been wholly repaid, and in respect of its freedom from anxiety over water undertakings the town is, the Author thinks, to be congratulated.

Water for domestic purposes is supplied at charges varying with the rateable value of the consumers' premises. Specimen charges are—

	Per annum. £	s.	d.
Rateable value not exceeding £3	0	7	8
„ „ „ 10	0	15	0
„ „ „ 21	1	5	8
„ „ „ 50	2	11	4

Water for one bath and one water closet is supplied with no extra charge. Users for trade purposes are charged 11*d.* per 1000 gallons, less discount at 5 per cent. if paid within one month of demand.

Previous to 1898, when the Author was appointed, 16,000*l.* had been already spent in re-sewering the district under the direction of James C. Haller, Esq., C.E., of Dewsbury. Since then 7,800*l.* has been expended, and an application for a further sum of 1,000*l.* is now before the Local Government Board, which will complete the sewers of the Cleckheaton and Scholes wards.

The whole of the sewage from Cleckheaton ward is connected to the Liversedge Trunk Sewer, and is treated by that authority, under agreement, for the sum of 900*l.* per annum.

The sewage from Scholes ward is treated on about 10 acres of pasture land by broad irrigation, and that from Oakenshaw by precipitation with aluminoferric, the effluent then being passed over a bed of clinker from the destructor. The effluent from both these works is generally approved by the Rivers Board.

The most important addition in recent times to the roadways of the district is that connecting Whitcliffe and Whitechapel roads. This road is 500 yards long by 36 feet wide, the bulk of the land required being given by the Low Moor Company. The total cost is 2,136*l.*

Whitechapel road from its junction with Bradford road to Scholes has been straightened and widened to a uniform width of 36 feet, the Author's estimate of this improvement being 6000*l.* Trees are planted at intervals along the kerb line, and a virtually new district has been opened out, besides giving better facilities for reaching the new cemetery which lies between Whitechapel road and the Leeds and Whitehall main road.

A burial ground (controlled by trustees who have been appointed by various religious bodies) nearing repletion the council decided to provide a suitable site, and acquired 16 acres of land for that purpose. The Author was instructed to prepare plans, etc. for submission to the Local Government Board, when, after due inquiry, a sum of 7,100*l.* was sanctioned, and the work carried out.

A low death-rate militates against the prospect of immediate profit from the cemetery. For the years 1900–3 the average rate per 1000 per annum was 14·48; in 1903 the rate of mortality fell to 12·88.

A mortuary chapel has been erected in a semi-Gothic style of architecture, which to the Author's gratification has commended itself to church and chapel goers alike. Cathedral tinted windows admit ample light, and the king post roof, the pews, lectern, and all internal fittings, are of pitch pine.

Heating is accomplished from the basement, the system being the low pressure hot water.

A vestry with lavatory accommodation is at the north end of the building. A mortuary is also provided, and on the east or opposite side a similar building is fitted as a waiting room for the convenience of mourners in bad weather.

There is also a house provided for the registrar, and an office.

The contractors for the various trades and the amount of their contracts are as follows:

		£	s.	d.
A. Drake	Mason	1470	12	7
R. Rodgers	Joiner	483	0	0
R. Broughton	Plasterer	83	10	0
F. Knowles	Plumber	254	10	0
S. Nutter and Son	Painter	83	6	6
Robinson and Crowther ..	Slater	139	0	0
„ „ ..	Boundary walls	1253	9	7
J. Hirst	Rails and gates	149	10	0
		£3896	18	8

Road making, drainage, laying out and planting were carried out by direct labour.

At the northern extremity of the burial ground a temporary iron structure has been erected as a smallpox isolation hospital.

Another hospital within the Cleckheaton area has been provided and equipped at a cost exceeding 10,000*l.* to serve the united districts of Cleckheaton, Hunsworth, North Bierley and Tong (the two latter being now part of the city of Bradford) created under the Provisional Orders Confirmation Act of the Local Government Board (1888).

Attention to public health is displayed in some sort by the provision of three recreation grounds at West End, Moor End, and Scholes of approximately 5 acres, 8 acres, and 3 acres respectively.

In addition there exist several small open spaces, and the feast field in which two feasts are held, one in the spring, and the other in the autumn.

A small market is held every Saturday; the Author has a scheme in hand for improving and extending this, which, when completed, will, he hopes, improve the appearance of the centre of the town.

The Private Streets Works Act, 1892, has been adopted, and a few streets made up, but much remains to be to done, and as time permits this will be undertaken.

ELECTRICITY AND DESTRUCTOR WORKS.

The combined works were opened on November 21, 1902, and were erected under the supervision of the Author; the electrical equipment being under Messrs. Gibbings and Baker, of Bradford and London.

The amounts borrowed were as follows:

Application **A**

CLECKHEATON URBAN DISTRICT COUNCIL.

Schedule of Plant and Material to be included in the Application to the Local Government Board for Borrowing Powers to obtain Loans for Electric Lighting and Traction purposes.

	£	s.	d.	£	s.	d.
Land	2287	0	0			
Buildings—				2,287	0	0
New buildings and economiser house	2990	0	0			
Chimney	1050	0	0			
Road making, sewering and water mains ..	1000	0	0			
Retaining walls and boundary walls for land	415	0	0			
Weigh house	45	0	0			
Shed for mortar mill, stone-breaker and macadamising plant	55	0	0			
				5,555	0	0
Machinery—						
Engine and dynamo sets (3—150 kilowatts)	4600	0	0			
Boilers (2)..	800	0	0			
Economiser	350	0	0			
Condenser, including motor and pumps ..	500	0	0			
Travelling crane	150	0	0			

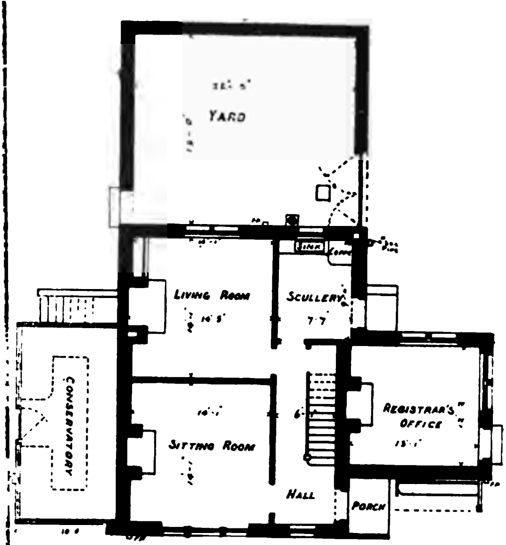
	£	s.	d.	£	s.	d.
Switchboards	350	0	0			
Destructor cells	2500	0	0			
Feed-water tank	100	0	0			
Auxiliary tank	20	0	0			
Steam and exhaust pipes, including valves	400	0	0			
Weighing machine	80	0	0			
Mortar mill	35	0	0			
Stone-breaker	40	0	0			
Macadamising plant	30	0	0			
				9,955	0	0
Accumulators—including cables and switchboard	1950	0	0			
Mains—				1,950	0	0
Feeder cable (lighting)	1000	0	0			
" (traction)	1500	0	0			
Distributor cable	1780	0	0			
				4,280	0	0
Transformers, motors, etc.—						
Motor to drive economiser	23	0	0			
				23	0	0
Meters	200	0	0			
				200	0	0
Other items—						
Professional charges	750	0	0			
				750	0	0
Total				£25,000	0	0

Messrs. Gibbings & Baker,
Consulting Electrical Engineers,
Bradford and London.

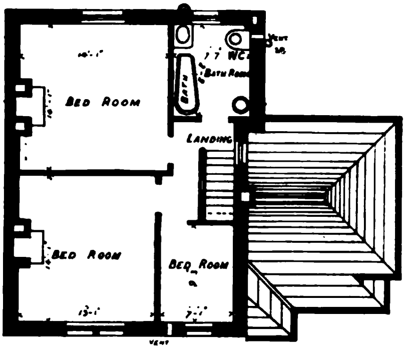
The buildings may be briefly described as being built of red brick with stone facings; the roofs of the boiler-house and engine-room have iron principals, boarded and slated with Welsh slates.

The destructor installation is by Messrs. Meldrum Bros. Ltd., of Manchester, and is known as the "Simplex Regenerative System." To each boiler is attached a furnace 12 feet by 6 feet 2 inches, lined with firebrick, having two door openings 3 feet wide by 1 foot 9 inches high, a bridge 18 inches thick, 18 inches high, and a combustion chamber at back of bridge 8 feet long by 3 feet wide and 8 feet 6 inches high; the whole covered by a 9-inch firebrick arch, sprung from cast-iron skew backs, in order that the side walls may be repaired without interfering with the arch. This is again covered with a 9-inch red brick arch with a 3-inch air space between the red and firebrick. The grates are constructed in two lengths of interlocking firebars, 2 feet 9 inches long, with a space between of ¼ inch, rising 3 inches at the back; the dead plates at the back of the

CEMETERY CHAPEL AND LODGE.



LODGE GROUND PLAN.



CHAMBER PLAN.

To face p. 144.

grates are 12 inches wide, and end dead plates 6 inches wide; a tee-piece resting on a division wall divides the ashpit into two parts or grates; the air supply to each grate of the furnace is supplied by two steam jet blowers of the well-known "Meldrum" type, fixed to the front of the cast-iron upright air-boxes, drawing hot air from the regenerator; this arrangement of blowers renders the forced draught silent. It will be seen that with such a combination an evenly high temperature can be maintained by careful and systematic firing, one grate being charged while the other is in an incandescent state. Thus the gases from the fresh charge mingle with the gases from the incandescent fire and become innocuous. The gases from the furnace pass over the bridge into the combustion chamber (the dust settling there) through the boiler, back underneath, returning along the side flues, and then to and through the regenerator tubes. The gases in the combustion chamber have a temperature varying from 1400° to 2000° F., sufficiently high to render all gases harmless and inoffensive. The air required for combustion is heated to between 300° and 350°, which is found of manifest advantage for such material as midden refuse, containing a large percentage of moisture.

The refuse is brought to the works in carts, up an inclined approach, and is tipped into hoppers having a capacity of 20 tons, measuring 23 feet by 5 feet by 8 feet high.

The destructor boilers are 26 feet long and 7 feet in diameter; two coal-fed Lancashire boilers 30 feet by 8 feet are also housed here; the accommodation provided in addition to the engine room being the electrical engineer's office, meter room, workshop, battery room, pump room, with the usual lavatory accommodation; the chimney is 150 feet high and 8 feet internal diameter.

The contractors for the various trades and the amount of their contracts are as follows:

		£	s.	d.
Robinson and Crowther	Mason and bricklayer ..	3589	0	0
" "	Plasterer and concretor ..	259	19	0
" "	Slater	182	0	0
J. Burnhill and Sons ..	Joiner	287	10	0
F. Knowles	Plumber	81	10	0
Nutter and Son	Painter	36	0	0
Cross and Cross	Iron roof	532	0	0
Meldrum Bros., Ltd. ..	Destructor, boiler setting, etc.	2421	10	0
		£7389	9	0

Road making and drainage were carried out by direct labour.

Mr. Albert Pickersgill, the electrical engineer to the Council, having kindly promised to give a paper describing the electrical equipment, working cost, etc., the Author does not purpose making any further reference to the works.

Gas Works.

Mr. George Niven, the gas engineer to the Council, has kindly furnished the Author with the following particulars.

The purchase of the gas works was completed in 1870 from the Cleckheaton Gas Company, at a cost of 53,000*l.*, the make of gas at that time being about 30,000,000 cubic feet per annum. Since the date of purchase, considerable extensions and alterations have been made to the works and plant, to meet the growing demands of the district, as at the close of last year the make of gas was 105,000,000 cubic feet; these alterations and additions cost about 12,000*l.*, but owing to the rapid developments which have taken place in the use of gas for tempering wire and other purposes, the profits of the department have been such as to enable the Gas Committee to pay off a large amount of the original capital; and instead of that item appearing on the yearly balance sheet as 53,000*l.*, it now only stands at 29,100*l.*, although the price of gas has been lowered from 4*s.* 6*d.* per thousand to 2*s.* 8*d.*, with discounts ranging from 10 to 15 per cent.

Cleckheaton ward is lighted by about 350 public gas lights and three electric arc lights. The cost of public lighting in gas alone is about 600*l.*, but no charge is made upon the ratepayers. The illuminating power required by the Act is 14-candle, but 17½-candle gas is supplied.

The number of consumers is 3000; the number of slot meters 1100; the number of gas stoves and cookers 250.

Mr. Councillor Thornton is chairman of both the gas and water undertakings.

The following is a brief description of the works.

The retort house contains five through arches, 20 feet through, and each arch contains eight retorts, D-shaped, 22 inches by 15 inches by 20 feet. The retorts are heated regeneratively; the settings are known as the semi-deep; each bed or arch is capable of producing on the average when fully employed from

120,000 to 125,000 feet of gas per diem, with a minimum of coke, say 11 lb. of coke per 100 lb. coal carbonised. The carbonising plant is equal to 600,000 feet per diem.

The condensers consist of six annular tubes, 30 feet high, and of such capacity as to enable the gas to be cooled below the temperature of the atmosphere if required, and are arranged in duplicate.

The scrubbing plant consists of two tower scrubbers, each 30 feet high, through which ammoniacal liquor is pumped in the required quantities.

The washer is by Holmes and Co., of Huddersfield, and is a very efficient machine, being capable of dealing with 800,000 cubic feet per diem.

The exhausters are two in number, with engines combined, made by Geo. Waller and Co., on the triple-blade principle, and are capable of exhausting 30,000 feet per hour each, or a total of 60,000 feet per hour.

The purifiers are six in number, with dimensions as follows: Four oxide boxes, 25 feet by 15 feet and 5 feet deep; two lime boxes, 14 feet by 14 feet by 5 feet deep.

The station meter is of the rotary type, and was the first of its kind fixed as a station recorder. It was made by the Rotary Meter Syndicate, of Manchester, and has proved itself to be a most excellent and reliable machine.

The gas-holders are two in number. No. 1, known as the works holder, has a capacity of 250,000 cubic feet. No. 2, or storage holder, which is fixed a little over a mile from the works, has a capacity of 500,000 cubic feet, thus giving a total capacity of 750,000 cubic feet. The heaviest output on one day up to the present is 549,000 cubic feet.

In conclusion, there only remain a few miscellaneous facts. The council is composed of thirteen members; nine represent the Cleckheaton ward, two members the Scholes, and two the Oakenshaw wards. The total number of houses approach 3000, and the total rateable value is put at some 21 per cent. below that of the gross estimated rental. The death-rate from zymotic diseases in the last year recorded was the low one of 0·93 per 1000, while infantile mortality returns indicate that the percentage of deaths at age less than one year was only 11·82 of the total of registered births. Differential rating discriminates in favour of the Oakenshaw ward, in which the general district rate is 2*s*. 6*d*. per £ against 4*s*. in Cleckheaton and Scholes wards. Adding the poor and educational rate of 2*s*. 10*d*., the totals are therefore 5*s*. 4*d*. in Oakenshaw and 6*s*. 10*d*. in Cleckheaton and Scholes wards.

DISCUSSION.

Mr. J. A. **Settle**: I have very great pleasure in proposing a vote of thanks to Mr. Lund for the paper he has given us, and the great trouble he has been to in connection with this meeting. I should like to have some information as to the miles of the tramways which are worked in the borough, the current supplied for traction purposes, and the car mileage worked per week or per annum by the power from destructor. Can we have the particulars of the steam generated from the destructor—how much from the destructor, and how much from the Lancashire boilers, and whether the two are worked together, or is the steam from destructor furnaces supplied to separate engine? Could Mr. Lund give us some idea of the cost of laying out the burial ground, both as to planting and draining?

Mr. W. **Welburn**: I have very great pleasure in seconding the proposition. I notice that the public are allowed the use of the laundry at the rate of 4*d*. per hour. I would like to ask Mr. Lund what the charge includes—does it include the use of hot water and soap? Then, could Mr. Lund give us the return, or, at any rate, the probable return on the year's work? There is nothing in the paper to show whether it is worth the while of a council to carry out these works, whether they pay their way, or if there is a deficit. There seems a tendency to provide every sort of convenience for working people, but we have nothing to guide us as to whether such works pay their way or not. The provision of a public laundry is engaging my attention at the present time, and information as to whether they are used or not to any extent by those for whom they are provided would be very useful.

Mr. J. E. **Sharpe**: I should like to ask if any trade effluent is admitted to the sewers, and if so, under what conditions, and what is the character of it. As to street works, I should like to know what kind of flagging is used.

Mr. F. **Massie**: I notice Mr. Lund says, "the county council pay to the district council the whole of the actual expenditure on main roads plus 5 per cent. for establishment charges." I have a case now with the county council in which, unfortunately, an accident happened on a main road on a foggy night—a man stumbled over a heap of road scrapings. The accident is going to cost the rural district council 15*l*. to 20*l*. to settle. The county council repudiate all liability for the accident. I mention this matter to let the members know that this 5 per cent. for establishment charges is not going to be all profit to them. Some time or other an accident like this is going to happen, and then all the profit disappears. With regard to motor traction for municipal work, I should be glad of any information that could be given by any member present. I have a very enthusiastic member of my council who wants a motor to drive the steam roller and to water the roads, etc. With regard to the purchase of water in bulk from the city of Bradford, we might be told at what price per thousand gallons it is supplied to Cleckheaton, and whether the town can distribute it to consumers without any charge on the rates at the not excessive water charges set out in the paper, considering there is no additional charge for a water closet and bath. With regard to the sewage disposal for the Cleckheaton ward, I should be very interested to know the population draining into the Liversedge sewerage system, and the quantity of trade effluent, for which the sum of 900*l*. per annum is paid.

Mr. W. H. HOPKINSON: With regard to the supply of water for the bath from old coal workings I should like to have the cost per thousand gallons. Is it as cheap as getting the water from the Bradford Corporation? There is another point in the paper, which I think very good, that is, the giving of land by the Low Moor Company for certain road widenings. I think the council of Cleckheaton are to be congratulated in finding landowers who are so generous as to give land for road-widening purposes. I don't think you will find many similar cases in the country. Landowners, and particularly companies, usually want a fair price for the land. Where people can be found to give the land required for the widening of streets, I think it behoves the council to take advantage of their generosity and make the improvements. I thought that I detected, in Mr. Lund's paper, a rather doleful note about the prospect of making a profit out of the cemetery. Instead of being doleful about it, I think Mr. Lund is to be congratulated upon the low death-rate, and if I were in his position, I would strive to keep the death-rate as low as possible, because I think it is as much to his credit as it is to the advantage of the town.

Mr. A. M. **Fowler**: I should like to ask a question on the matter of trade effluents—a subject already referred to. It is a very important question, and one on which the trade of the country is somewhat dependent. The more I have considered this question, the more I am convinced that the municipal engineer should give careful consideration and attention to it. It is not only a question of the effluent which is discharged from the manufactories into the sewers, and which comes on to the sewage disposal works for treatment, but it is the obtaining of the water of which that effluent forms a part and its utilisation for purposes of public use. In some of our large towns the quantity of effluent water is of considerable volume. In Manchester there are something like 36 million gallons a day flowing into the Ship canal. Mr. Gilbert Fowler, the analyst and chemist there, told me that the effluent water they are now producing at the Manchester sewerage works is quite up to the standard of the Irwell and Mersey rivers committee. Now, if that be so, the effluent water is practically as good as some of the Thames supplies and some of the drinking supplies in the country. As you know, some thirty years ago I brought forward the question of supplying millowners with the effluent water of sewage works. I have since gone very fully into the question of supplying this water to the millowners for condensing and manufacturing purposes, and I find that the water could be distributed to millowners at something like 2½*d.* per thousand gallons. We are men of progress, and should have no sentimental objections when the facts are before us. The cost of sewage undertakings is a very serious matter, and no one is so heavily handicapped by this as the sewage engineer. The gas engineer, the electric light engineer and the water engineer all get congratulated because of the financial return derived from their undertakings, but the sewage engineer does not, because there is no possibility of profit. I was reading the other day the prospectus of the Johannesburg Corporation loan, and among the works for which money was required, was 80,000*l.* for sewerage works, which it was said would be self-supporting. I doubted the accuracy of the statement. Anyway, it would be entirely different from our experience in this country. If we could utilise this effluent water and sell it to the millowners at 2½*d.* per thousand gallons, it would greatly improve the position of the sewerage undertakings of our large towns. When I was at Leeds, I pumped the water there, taking every cost, for less than 2½*d.* per thousand gallons, allowing for distribution, and I know that I could pump it and distribute it for Manchester at 2½*d.* per thousand gallons. The question of trade effluents is a serious one. We are the custodians of the public funds, and have to safeguard the public health, and we are not doing our duty to the community and to the millowners if we do not seek in every way to supply a sufficient quantity of water at a reasonable rate. You know perfectly well that in a large town you never get a water undertaking completed before you want to supplement the supply. Take Manchester and the Thirlmere supply. The consumers were bordering on a water famine before they got the second pipe line laid. Yet they were selling water to the manufacturers for trade purposes, and the public were almost starving for water. It is our duty to take a broad view of this question and think of the great benefit a cheap supply of water would be to the millowners and to the community. I am very pleased to have been here to mention this matter.

Mr. S. S. HAYWOOD: Mr. Lund mentions in his paper about the paving of the margins between the tramway track and the kerb. I should like to know if all the tramways are laid on main roads, and what is the greatest width he is able to persuade the county council to pave in substitution for macadam. Then as to the destructor, Mr. Lund gives no details as to the cost per ton of burning the refuse. If he has those figures they would be useful, and also the cost of collection. Mr. Lund includes in his paper the cost of a macadamising plant. I should like to know whether he has utilised the plant yet, and if so, whether he has any costs in tar or labour per ton of tarred macadam produced.

The PRESIDENT: First of all, I should like to say a word or two in reference to the matter touched upon by Mr. Massie—the 5 per cent. for establishment charges generally allowed by county councils to district councils for the repair of main roads. Mr. Massie thought 5 per cent. was not at all excessive when it is considered that it has to cover extraordinary expenses occasionally, such as compensation for accidents on the roads. I think it would be scarcely right for county councils to take that into consideration, because if they did it would be putting a premium on carelessness. Where sins of commission take place in matters of road maintenance we know very well the law steps in and protects the people who meet with accidents caused thereby. There is no responsibility in a case of nonfeasance, but there is for misfeasance, and if people tumble over anything which is left lying on the roads, the authorities are liable to pay for the damage sustained. Arising out of that is another matter. I think the county council of the West Riding is very generous in allowing the whole cost of maintenance of main roads. I am one of those who believe that the word "towards" means something not quite the whole. I see here the whole cost is allowed, and therefore in this particular case I do not think it would be wise for this council to ask for anything more than they are now receiving, especially as they are allowed an additional 5 per cent. for establishment charges. The sum of 60*l.* per annum is given as the average cost of watering the roads. I suppose that means the whole cost. It is not particularised in the paper as the cost of watering the main roads; therefore I take it to be the cost of watering the district roads as well. If so, I do not think it is excessive. It would be something like 3*l.* per mile. I notice the non-slipping artificial flag is used here, even in the heart of Yorkshire, where they can get the natural material. I would like to ask whether it is better, not only in the matter of price but of foothold, than the natural flag. I congratulate the town upon having such a nice water for the baths. I had a plunge into the soft water of the Elan, in Birmingham the other day, and I found it to be about the colour of brown paper. It is a beautifully soft, and doubtless a good, water, but it is certainly unattractive in colour. As to the provision of a public laundry, I should like to know whether that privilege is appreciated and whether the people take full advantage of it. I should also like to know the cost per thousand gallons of water purchased from the Bradford Corporation. I notice from the paper that Cleckheaton ward is lighted by 350 public gas lights and three electric arc lights. Would Mr. Lund be good enough to say whether, with the gas lamps, the incandescent mantle is used, and if so, whether he has any figures as to cost and efficiency?

Mr. C. LUND, in replying to the discussion, said: We borrowed

7100*l.* for the cemetery, and have expended the whole of it. The site was 16 acres, the land cost 70*l.* per acre. The rest of the money, after deducting the amounts given in the list of contractors, has been spent on drainage, road making, planting, and laying out.

For the use of the laundry we charge 4*d.* per hour. That includes hot water, and the use of washing and wringing machines, and a mechanical drier. The privilege is not appreciated to any extent by the public. The laundry is certainly used, but not to any great extent.

The next question was, the cost of pumping water for the baths. If you refer to the paper you will find that the two swimming baths take 50,000 gallons of water. This is pumped and heated at a cost of 9*s.* for the 50,000 gallons.

As regards trade effluents, we take only such as we are compelled to do by law. I may say we are very particular to see that they keep the whole of the solid matter out. The manufacturers are required to have settling tanks, and in some cases duplicate tanks. We inspect these tanks intermittently. The manufacturers are very good here in keeping the solids back. We have nothing to find fault with in that respect.

In regard to private street works, we have not done very much in this line. We have streets made up both of macadam and Yorkshire setts. The narrower streets we have paved; if they are fairly wide we allow macadam to be used. I don't believe in that myself; I consider that all private streets should be paved. But, as you know, I am not the sole arbiter in this matter.

As to the 5 per cent. allowed by the county council for establishment charges in connection with the maintenance of main roads, we have tools to provide out of that, so it is not all profit.

The price charged for water supplied by the Bradford Corporation is 9*d.* per thousand gallons. There is a small profit made on the distribution of the water. I think we compare very favourably with other places as to our price for water, especially when compared with towns which have not their own water supply. The mains in our streets cost us nothing, as the whole of the capital charges have been paid off.

The population draining into the Liversedge sewer is between 9000 and 10,000.

As regards by-laws, we have the model by-laws in force in

Cleckheaton. As you know, the by-laws are difficult to carry out in their entirety, but we do our best with them, and on the whole we carry them out satisfactorily.

Mr. Haywood mentioned the paving of the margins. The county surveyor has allowed us to pave up to 5 feet, and in the case of a part of a road which had no foundation, he allowed us to pave the whole of such part.

As to the cost of collecting the refuse, I have not the figures with me. That work is under the sanitary inspector, but if any Member wishes the figures, I will obtain them for him.

As to the macadamising plant, I have not yet used it. It is simply making use of the waste heat from the destructor. I have had some horizontal cast-iron plates put over the flue to dry the stone on.

The cost of the street watering is reasonable. We put a good deal of water on the roads, but it is the same water as we use for the bath, and costs us nothing but labour and pumping.

With reference to the use of artificial flags, I do not think they have the same life as the natural stone, but they are more easily cleaned, have a very good appearance, are free from laminations, and are also cheaper.

The PRESIDENT: What price are they?

Mr. LUND: 4*s*. 6*d*. per yard. They are perhaps 6*d*. a yard cheaper than the natural stone.

The gas engineer will say something about the incandescent mantles. The cost of lighting is given in the paper. Personally I am of opinion that the incandescent mantles are not a success for street lighting; there is so much damage with them. They are very often going wrong; but Mr. Niven has much more experience with them than I have.

Mr. G. NIVEN: I have made observation of the life of mantles in Cleckheaton. We have only about two dozen in the whole town; we have not gone in for mantle lighting on any large scale. I suppose the reason that I have not pushed mantle lighting in Cleckheaton, is due to the fact that we have the electric light works—and those electricity works have to be established. While I am very proud to know that in our Mr. Pickersgill we have a very able engineer, and a gentleman with whom it is very pleasant to get along, yet I dare to say if I were to take to incandescent mantle lighting, I should have no difficulty at all in proving both to my committee and the ratepayers, and to Mr. Pickersgill in particular, that I could give a cheaper and a better light. Now I want it to be understood among you gentlemen that the feeling in Cleckheaton between the officers is a very pleasant one. We have the interests of the town at heart, and it would ill become one officer to put obstacles in the way of the other, until he got his works fully established and making a profit. As to the life of the mantle, there is something peculiar. I have a lamp with two burners on the new bank; on the one burner I have a mantle that has been on eight months. On the other burner, I have had five mantles during the eight months, and for the life of me I cannot tell how it is they go so quickly. I have put screens in the lamp; I have turned the burner round; changed the mantles; but this mantle is there and has been there for eight months. We change the mantles on the average about once a month. In mantle lighting, we don't want to make the mistake which has been made in most towns of putting in mantles for the ordinary lamps. The draughting of the lamps wants attending to, and beside that you want to have your lamps properly fixed, because the vibration of heavy traffic has a great deal to do with the life of the mantle. With careful manipulation and decent lighters, you ought to get a mantle to last at least a month or six weeks.

CLECKHEATON ELECTRICITY AND DESTRUCTOR WORKS.

By A. PICKERSGILL, Electrical Engineer.

The Urban District Council obtained their provisional order in 1900, and afterwards Messrs. Gibbons and Baker were engaged to draw up a scheme for the supply of energy for power and lighting purposes.

The scheme adopted was the three-wire continuous-current system with a pressure at the consumers' terminals of 230 volts, and 460 volts across the outers, the middle wire being earthed at the station through a recording ammeter. This system has several advantages, one being that the same machines may be used for either lighting or traction purposes, and when conjoined with a motor-generator one machine can be made to fulfil both duties (lighting and traction) at light loads.

Buildings.

These were designed by the surveyor, Mr. C. Lund. It will be noticed that these buildings are essentially useful ones; money has not been wasted in giving extravagant frontages, or offices, but on the other hand, the buildings have been designed to give ample accommodation for the plant erected and also readily lend themselves for easy extension should occasion arise.

Boiler House Plant.

The boiler house contains four boilers of the Lancashire type: two are 30 feet by 8 feet and are fired by coal, and two are 26 feet by 7 feet and are fired by refuse being worked in conjunction with a Meldrum's Patent Simplex Regenerative Refuse Destructor. All four boilers are designed to work at a pressure of 180 lb. per square inch, and each is fitted with the usual complement of safety-valves, etc.

ECONOMISER.

A Green's economiser has been installed, consisting of 192 pipes, and is capable of raising the temperature of the feedwater from 100° to 280° Fahr.

Arrangements have been made for adding a further section of 96 pipes, should this become necessary.

ENGINE HOUSE PLANT.

The original plant consisted of three Belliss and Morcom engines, each 300 I.H.P., coupled to three dynamos, each of 150 k.w., made by Messrs. Johnson Lundell.

A further set has recently been erected consisting of one 610 B.H.P. engine by Messrs. Gourlay Bros., of Dundee, coupled to a 350 k.w. dynamo made by the Phœnix Dynamo Manufacturing Company, Bradford. All the dynamos are arranged to run as shunt machines for lighting purposes, giving current at 460 to 520 volts, and as compound machines for traction, giving current for the latter purpose at 500 to 550 volts.

There is also a motor balancer for assisting in the regulation of the system, two booster dynamos for charging the end cells of the battery, and one negative track booster for tramway purposes.

SWITCHBOARD.

The switchboard was constructed and erected by Messrs. Dorman and Smith, of Manchester, and consists of twenty-three panels.

On the extreme left there are five traction feeder panels, each containing main circuit breaker, knife switch, ammeter and lightning arrester.

The following panel contains all the gear and instruments for working the negative traction booster. A Board of Trade panel is also fixed, carrying all the necessary instruments required for the testing of the feeders, etc.

A meter panel for recording all energy leaving the works for traction purposes has been fixed.

Each of the four main dynamo panels are fitted with maximum and minimum circuit breakers, three-way switches (to enable the operator to use any machine for either lighting or traction), one Still's patent shunt breaking switch, field-regulator, and an ammeter.

The balancer and booster panel is fitted with maximum circuit breakers, starting switches, and the necessary field regulators, ammeters, voltmeters, etc.

The balancer can deal with an out-of-balance current of 100 amperes.

The booster output is 50 amperes at 10 to 70 volts.

Two large battery regulating panels have been fixed, each being connected to forty cells, one on the positive and the other on the negative battery, the middle wires being coupled up through two Aron wattmeters, and afterwards led to the middle wire 'bus-bar.

Two lighting feeder panels are at present in use, and a further three panels have been provided for extensions.

BATTERY.

The battery comprises 270 cells, made by the Electric Power Storage Company and known as P. 11. type, capable of discharging at a maximum rate of 250 amperes for one hour, or at a rate of 50 amperes for ten hours.

AUXILIARY PLANT.

This comprises one jet condenser, with an Edwards' patent air-pump, one centrifugal pump capable of lifting 30,000 gallons of water per hour, and two boiler feed pumps, each having a capacity of 1000 gallons per hour.

All the above are electrically driven by motors made by the Lancashire Dynamo Company, thus being able to demonstrate to intending consumers the reliability and different uses to which electrical energy is adapted.

MAINS.

The whole of the feeders and distributing mains included in the original scheme were manufactured and laid by the British Insulated Wire Company, Limited. These were laid solid, in wood troughing filled in with refined pitch.

All extensions have been carried out by armoured cables laid direct in the ground and protected by a layer of bricks.

The size of the feeders is 0·25 by 0·1 by 0·25, and the distributing mains 0·0789 by 0·035 by 0·0789.

Lamp Connections.

At the opening of the works on November 21, 1902, the number of consumers was six, having a total connection of 530 8-candle power lamps, and at the present time the number of consumers equals 71, having a connection equivalent to 6100 8-candle power lamps.

The price charged for lighting is 5*d.* per unit less 5 per cent. discount, and for power as follows.

All charges for power are based on a minimum consumption of 200 units per quarter per horse-power of demand, the minimum quantity at 2*d.* per unit, and all units over the minimum at 1*d.* per unit.

The following discounts will be allowed off the account for current where the total quantity used exceeds the minimum by the following percentages:—

Up to and including minimum	**Discount at the rate of**	**5**	**per cent.**
Between minimum and 50 p.c. over minimum,	**,, ,,**	**7½**	**,,**
,, 51 p.c. and 100 ,, ,,	**,, ,,**	**10**	**,,**
,, 101 ,, 150 ,, ,,	**,, ,,**	**12½**	**,,**
,, 151 ,, upwards	**,, ,,**	**15**	**,,**

The station also supplies current to the Spen Valley Light Railway, an agreement having been entered into for this purpose whereby the company agree to take not less than 400,000 units per annum, with a fixed maximum demand not exceeding 350 kilowatts.

The prices arranged under this agreement are as follows:—

For the first 400,000 units 1·5*d.* per unit; for the next 100,000 units 1·4*d.* per unit; and all above this amount at 1·3*d.* per unit.

It will thus be seen that the council have an assured income of 2500*l.* from this source alone.

In concluding this portion of the paper, the Author might state that the scale of charges to private consumers is under consideration for revision, and it is hoped that such revision will lead to a considerable increase in the number of consumers.

DESTRUCTOR.

The destructor is of the well-known Meldrum regenerative type, and consists of two units, each having its own combustion chamber regenerator and Lancashire boiler. Each unit has two grates, having an area of 25 square feet or 50 feet in each unit.

The capacity of each unit is 20 tons in twenty-four hours : this is equal to burning 37 lb. per square foot of grate per hour. The front feed method of firing has been adopted. The refuse is tipped into bunkers opposite each unit, and is then thrown into the furnaces by hand. The clinkering is also done from the front, and so far the results have been satisfactory. The Author is of the opinion that to further describe this portion of the undertaking would be useless, as most if not all the gentlemen present are fully conversant with this type of destructor.

There is, however, a subject appertaining to this department which, when worked in conjunction with an electricity works occasionally gives rise to considerable friction between the two departments in many towns. The Author refers to the amount which should be paid for steam supplied to the electricity department from the destructor.

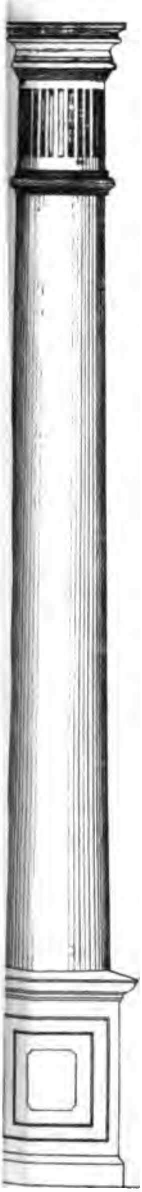
There are several methods which have been adopted, but none seem to have given satisfaction.

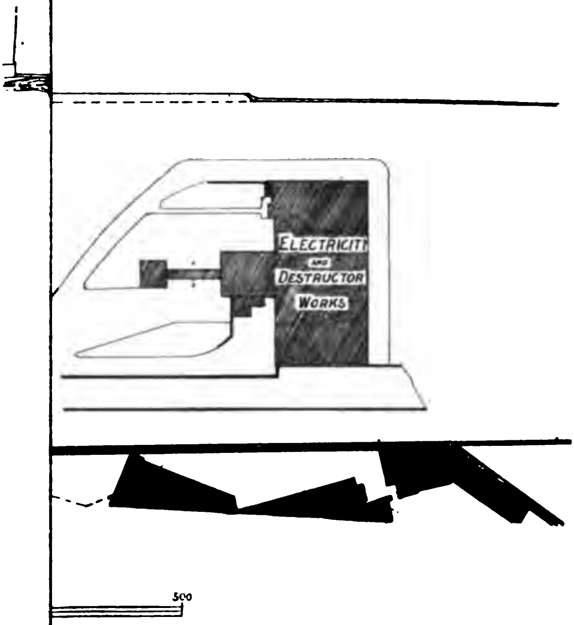
The Author has, however, propounded a scheme which seems fair to both departments, and which has been adopted by this council as a basis for the conjoined working.

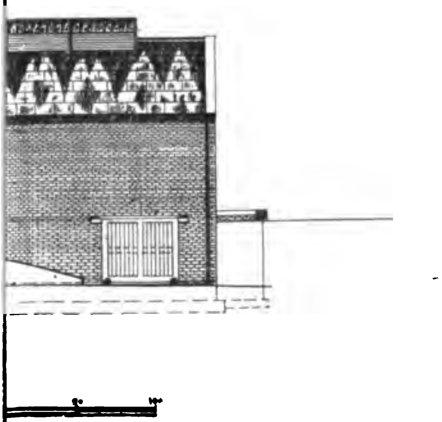
The arrangement is as follows :—

The total wages paid for stoking is ascertained, and of this a sum of 218*l.* 8*s.* is debited against the electricity department as its proper share for stoking the coal-fired boilers, the remainder being debited to the destructor department as its proportion for burning the refuse. The total cost of coal per unit sold is now obtained, and credit is given for steam supplied, so that the total cost per unit for coal shall equal 0·3*d.* The following example will no doubt make the method perfectly clear. Suppose the total wages paid during the year for stoking amount to

STRUCTOR WORKS—PLATE I.







To face p. 160.

450*l.* of this total, 218*l.* 8*s.* is paid by the electricity department as its share for the stoking of the coal fired boilers, the remaining 231*l.* 12*s.* being paid by the destructor department for burning refuse.

Now assume that the total number of units sold are 480,000, and that the amount paid for coal is 400*l.*, this would amount to 0·2*d.* per unit sold; you now credit the destructor department with such a sum as will bring the total costs for coal to 0·3*d.* per unit sold, the amount in this example being 200*l.*, thus leaving the net labour costs of destroying the refuse at 31*l.* 12*s.*

This method, the Author thinks, is most equitable, he having made several tests in order to find out what was the cost in coal per unit sold when the destructors were shut down.

It should never be overlooked by the members of any council, that the primary object in erecting a destructor is the proper and efficient destruction of the town's refuse, and that this should be carried out independently of any by-product or income from such undertaking.

At the same time full value should be paid by any other department for steam or power which is supplied therefrom, and the method devised by the Author seems to him to be a step in the right direction so far as a conjoined electricity and destructor works is concerned.

DISCUSSION.

Mr. J. **Parker**: We all know that with the destruction of refuse, there is an element which far outweighs £ *s.* *d.*—the getting rid of the intolerable nuisance which follows the stacking of house refuse. When we can remove such nuisance, and at the same time make a profit, this question of destruction of refuse, and the utilisation of the waste heat, becomes, for sanitary engineers and surveyors, one of the great problems of the day. I happen to have had experience of refuse destruction extending over nearly ten years, and was the very first to start a refuse destructor to utilise the waste heat. At Hereford we utilise the heat for pumping sewage; here, in Cleckheaton, it is being used for electric lighting. Our pumping installation, previous to the utilisation of the destruction, was maintained by coal-fire boilers. At that time we were paying between 600*l.* and 700*l.* a year for coal. We put Meldrum's refuse destructor in front of the existing Galloway boilers, and allowing for extra stoking, we saved the first year 550*l.* in hard cash. In addition to that an injunction which had been filed against us to prevent us tipping the refuse, was got rid of. I was very much struck with the moderate cost of the installation of the destructor. The whole amount is 25,000*l.* For such an output as three 150 kilowatts engines and dynamos and two boilers, that is exceedingly cheap. As to the loan, I presume you would get the land for forty years, and the building and machinery for fifteen years.

Mr. LUND: For periods of twenty-five and thirty-five years.

Mr. J. PARKER: I think it is very creditable indeed, and I anticipate you will get very good results from the destructor. It is certainly a little more trouble, and there is a little more dust and dirt. For that reason electrical engineers do not like it, but they have to get used to it. Anyone who reads these two papers must admit that they demonstrate the progressive character of the Cleckheaton Urban District Council. I may say that at Hereford, although we have only a refuse destructor at the outfall works, we are now about to put in a third boiler at the electricity works. That is the reason I came here to-day, to see what, if any, improvements have been made, and how the destructor heat is applied to electricity. As our electricity works are in a residential district, the Chairman of the Committee at first thought we had better keep to coal-fired boilers, as there might be opposition at the Local Government inquiry, but the opposition never came. I have much pleasure in proposing a vote of thanks to Mr. Pickersgill for his very interesting paper.

Mr. E. J. SILCOCK: I have very great pleasure in seconding the vote of thanks to Mr. Pickersgill, which has been so ably proposed by Mr. Parker. I must say that the paper is a very interesting one to me, because the destruction of refuse has always been a pet subject with me. I fully agree with the Author's closing remarks in which he says, "it should never be overlooked by the members of any council that the primary object in erecting a destructor is the proper and efficient destruction of the town's refuse, and that this should be carried out independently of any by-product or income from such undertaking." I think we should all of us impress upon our respective councils the great importance of keeping that principle always fixed in their minds. It is no doubt a very pleasing thing to show a large saving on the coal bill by the destruction of refuse in combination with electric lighting or the pumping of sewage, but the prime object of a destructor is the destruction of refuse, and in most cases that cannot be efficiently done, if the best results are endeavoured to be obtained in the shape of thermal efficiency. Of course, it depends to a very great extent upon the nature of the refuse which has to be destroyed, and this afternoon when we visit these works, we shall no doubt have the opportunity of seeing the quality of the refuse which has to be destroyed at Cleckheaton. It also depends upon the situation of the destructor. If the destructor is on a site away from buildings, the storage of the refuse is permissible, but in large towns and cities, in order to be economical the destructors must be erected near to dwelling houses, and consequently it is in those circumstances most important that the refuse should be at once destroyed, and that it should be destroyed in such a manner as to get the highest possible temperature and the least risk of any fumes of a dangerous character passing away from the destructor. I think that is a most important principle to be borne in mind.

The vote of thanks was accorded with acclamation.

The Members were then entertained to luncheon, and the afternoon was occupied with visits to the infectious diseases hospital, the gas works, and the electricity and destructor works.

MIDLAND DISTRICT MEETING AT BIRMINGHAM.

April 1, 1905.

Held in the Lecture Theatre, University of Birmingham.

A. T. Davis, M. Inst. C.E., President, *in the Chair.*

Mr. H. Richardson, Hon. District Secretary, read the minutes of the last Midland District Meeting, which were confirmed.

The President: I feel sure we shall have from Mr. Bamber a most interesting paper on an important subject, and I am very glad to see so large a number of Members present to participate in the proceedings.

Mr. Bamber then read his paper, which was profusely illustrated by biograph and other pictures, and M. De Vesian exhibited on the screen a number of examples of construction in ferro-concrete work, including bridges at Rochdale and Liverpool, grain silos at Swansea, and stores for the Great Western Railway at London and Bristol.

PORTLAND CEMENT.

By H. K. G. BAMBER, F.C.S.

In rising to address this audience the Author must first claim indulgence for the presentation of his remarks in a somewhat condensed form necessitated by the very short space of time at his disposal. He may assume also that the majority of his audience are somewhat familiar with the subject, and that it will not therefore be necessary to go in detail into the ancient history of Portland cement, but rather to confine his remarks to the more recent development in the processes of manufacture of this most important building material.

You meet with it in almost every form of building construction—in huge masses in the form of concrete foundations, in which position its strength and constancy of volume are relied upon to support the whole of the superincumbent weight, frequently with very heavy and varying loads. In the most recent practice of building construction, and one which is rapidly coming to the front, it is used almost exclusively in conjunction with steel and iron for the whole of the superstructure, entirely superseding brick, timber and other forms of light construction.

Without this material some of the largest and most important works in the world could not have been accomplished, such as docks, harbours, waterworks, etc. Of the latter the Corporation of Birmingham possess perhaps the finest example in this country in their enormous reservoirs in the Elan Valley, the immense dams, impounding acres of water, being constructed almost entirely in Portland cement concrete in conjunction with stone as facing; the strength of the whole construction, however, depending upon the strength obtained in the enclosed concrete. It has been the Author's privilege to visit these works on frequent occasions. The supplies of the whole of the Portland cement amount to some 90,000 tons up to the present time; and, with some knowledge of the subject, the Author is able to say that he has never seen more magnificent concrete work, due primarily to the excellent quality of cement, but chiefly to the great care and ability applied in its use. Without Portland cement it is safe to say that Birmingham would never have obtained its water supplies from the Welsh mountains.

Having realised the immense value that Portland cement has been in the past and is still more likely to be in the future in the hands of the engineer, let us turn our attention to some of the more recent methods of manufacture of this material. Shortly, the old process consisted of mixing together chalk and clay (for many years the only materials used) in definite proportions; a difficult matter when it is remembered that it is only in recent years the assistance of the trained chemist has been utilised to check the composition in the early stages of manufacture, and that formerly this was done entirely by rule of thumb, the material frequently reaching the final stages of manufacture before defects were discovered arising from improper proportions of raw materials, which defects it was then practically impossible to remedy. After mixing, the material was then pumped or elevated into "backs," or reservoirs, where settlement could take place, and a considerable percentage of the water used for amalgamating the chalk and clay could be removed by decantation and evaporation. This mixture of chalk and clay was then removed by hand or pumped on to drying floors or chambers over the kilns, where the water remaining therein was evaporated by heat obtained from the process of calcining, to which process in its turn the dried material was subjected. The resulting clinker was then ground to a powder, producing the Portland cement as known to the trade.

The development of research, and the carrying out of properly organised investigations into the manufacture and properties of Portland cement, more especially in Germany and America, compelled the English manufacturer, who had been somewhat tardy in this direction, to set about putting his works in order, and remodelling them on scientific lines. The extension of knowledge of the subject soon resulted in other calcareous and silicious materials being experimented with for the manufacture of cement, and in many cases such materials, other than chalk and clay, have been found suitable under proper methods of manufacture for the purpose, with the result that works have sprung up in various parts of the country.

As one of the Author's objects is to bring to your notice the correct methods for practically testing cement, the various processes of the more modern manufacture will be shortly described, so that in dealing with the question of testing, it will be possible to trace back to each particular process of manufacture the conditions which are, and must be, applied by the manufacturer to obtain a finished product which shall possess those qualities that will enable it to successfully pass the various tests required of it, and which will later have our consideration.

Great care is taken to remove from above the chalk all "callow," i.e. gravel, loam, sand and hard contaminated chalk, locally known as "bull head," so that none but the pure chalk is used for the manufacture. As the supplies of chalk immediately contiguous to the works have long since been worked out, it has been necessary to go further inland for material, necessitating steam or other traction to bring the raw material to the works.

The chalk and clay obtained are brought into the works and there carefully mixed by means of powerful machinery in fixed and definite proportions, in accordance with the requirements of the specification under which it is intended the cement manufactured therefrom is to be supplied.

The principal object of this part of the process is to get the materials mixed in exactly the proper proportions, and this is done by the most careful and continuous system of sampling and analysis while mixing is going on. Samples are taken every fifteen minutes, and so regular is the composition of the chalk and clay used, that the chemists in charge of the various plants, working under a properly organised system, have no difficulty, by means of chemical tests, in keeping the proportions well within the prescribed limits.

The method adopted is to determine the amount of carbonic anhydride (CO_2) present in an accurately weighed amount of the dried mixture of chalk and clay. Chalk ($CaOCO_2$) consists of 56 parts of calcium oxide (CaO) chemically combined with 44 parts of carbonic anhydride (CO_2) and it can only occur in these fixed and definite proportions. By taking, therefore, an accurately weighed quantity of dried "slurry," and determining by means of proper apparatus the amount of CO_2 present (which can be done with great accuracy and rapidity), the amount of calcium carbonate present in the mixture can be immediately calculated. In addition to this, the precaution is taken of igniting another weighed quantity of the same dried sample and determining the loss of weight; which latter consists of all the carbonic anhydride (CO_2), and also any organic peaty matter that may have been introduced with the clay. By means of these two tests, carried out by thoroughly skilled chemists, the exact amount of calcium carbonate in the mixture is accurately determined; and seeing that both operations can be conducted and finished in a comparatively short space of time, a thorough knowledge of the composition is always available to the chemist, who makes slight alterations in the proportion of materials whenever his tests show that such alterations are necessary. In this way the manufacturer, with the aid of chemistry, keeps his mixture exactly as required.

Having insured this, the next important step is to see that they are thoroughly amalgamated, in order that, when later the materials are submitted to calcination, the atoms going to make up the same may be in the closest possible juxtaposition. The chemical combination of the raw materials, when submitted to the necessary process of calcination, is very much more perfect than when the particles are appreciably larger and not intimately mixed; in fact, the combination of the silica and alumina of the clay with the lime (after the elimination of the carbonic anhydride from the chalk) can never properly take place unless the materials to be calcined are in the finest possible state of subdivision.

In the modern cement plants, so perfectly is this part of the operation carried out, that at least 96 per cent. of the chalk and clay delivered to the mixing and grinding mills is capable of passing through a sieve having 32,400 holes per square inch before it is delivered by the mill for conveyance to the storage mixers.

Having brought the raw materials up to this point with a known composition, fineness and fluidity, the mixture of same —technically known as "slurry"—is pumped into large storage reservoirs, each having a capacity of slurry sufficient to make 600 tons of cement. In this way is secured a more perfect mixture, as the slightest variation experienced in the washmills is corrected again at this point by mixing in large bulk. Very great improvement in the quality of the product is obtained by this thorough process of incorporation, previous to the process of calcination, which immediately follows—the slurry in the mixers not being withdrawn until certified by the works chemist that same is in every respect in accordance with requirements.

The processes so far described refer exclusively to that known as the "wet," by which process in the United Kingdom the bulk of cement is manufactured. In some localities, however, the raw materials, consisting of a crystalline limestone more or less pure and a shale clay, or marl, are more conveniently amalgamated by what is known as the "dry" process. In this the materials, as obtained from their original source, are dried by some mechanical or other means, and are then mixed together in the dry condition and reduced by some form of grinding machine to a fine powder, by which an intimate mixture is obtained. The same care and attention chemically are required in this as in the wet process, more especially as it does not lend itself so satisfactorily as the wet for mixing the prepared raw materials in bulk. The dry process has advantages, however, in other directions, such as in economy of fuel, sufficient only being required to expel the moisture naturally present in the raw materials; whereas, in the wet process, the moisture added for the purpose of intimately mixing the raw materials in a state of suspension has to be eliminated by means of decantation, as in the old "back" process, or by evaporation.

We now come to the second part of the process, which is entirely of a chemical character—the first part being purely mechanical. More attention, perhaps, has been given to improvement of this part of the process than to any other. Many forms and descriptions of kilns have been tried, but as they all necessitate very heavy charges for labour, and the fuel used is essentially coke—a relatively costly fuel, and one liable to unexpected and artificial fluctuations in price—they have not met with much economical success.

Among the most economical of these kilns is the Hoffman (which can be used only in cases where cement is made by the dry process).

Other types of continuous kiln are those known as the shaft kilns. These consist of a vertical shaft with openings at the bottom for removing the burned clinker. The raw material and the fuel are fed in at the top of the kiln, as the materials fall therein, when the clinker is drawn from the bottom end.

Either of these kilns is adapted for use in connection with the dry process, the dry powder being pressed in the form of bricks previous to calcination.

The most familiar forms of kilns on the older process, however, and those adapted to the wet method, are known as chamber kilns, consisting of the closed kiln of ordinary lime-kiln type, having a considerable area of flue attached, constituting the drying floor for the wet raw materials; the hot gases from the burning charge passing over and under a further supply of wet raw material, expelling the moisture therein, and leaving it in a dry condition fit for the next charge of the kiln.

With all these kilns the operator has little or no control of the temperature at the part of the kiln where calcination is going on; and, as the material must necessarily be burned in fairly large pieces, so that the draught of the kiln is not impaired, a considerable portion of the product gets over-burned on the surface, leaving frequently a core of "half-burn," which it is difficult to remove, and which has a tendency to cause unsoundness in the finished cement.

The process of burning with rotary kilns was tried as far back as 1885. Although a measure of success was obtained at these early trials, many difficulties presented themselves which at that time appeared to be insuperable. The use of pulverised coal had not come into practice at that time, and great difficulties were experienced in burning with producer gas. No satisfactory material could be found for lining the hottest part of the kiln; and owing to the shortness of the kiln—being only about 25 feet in length—no economical use of fuel could be obtained.

The ideas originated in the Ransome process were, however, lately developed in the United States, where the use of petroleum as fuel removed a great many of the early difficulties experienced in the experiments in England. The process was eventually brought to perfection. The process developed very rapidly in America, and the rotary kiln is, in almost all works in that country, adopted for the calcination of Portland cement.

The prepared slurry—instead of being dried on "ovens" and "chamber kiln floors" with heat from the intermittent (old method) kilns, from which it is eventually to be removed when dry and packed with coke into these kilns at great expense for labour—is pumped from the mixers already described in a thoroughly homogeneous condition into the rotary kiln, down which it passes as the kiln rotates, the water being driven therefrom by the heat from the escaping gases evolved at the lower or calcining end of the kiln, where a temperature of from 2800° to 3000° F. is continually maintained.

The kilns are, in some cases, 70 feet long, and in more recent practice 80 feet long and 6 feet in diameter. The power for rotating the kilns is obtained by means of electric motors, and the variations of speeds of rotation, necessitated by continual atmospheric changes, are entirely under the control of the operators in charge of the several units.

The temperature necessary for calcination at the lower end of the kiln is obtained from the combustion of pulverised bituminous coal, which is forced into the kiln by means of an air blast, or other means, where it immediately ignites. The supply of coal in regular quantities as required, the economy and efficiency of the process, and the regularity in the qualities of the finished product, depend largely upon the successful working of the machinery of this portion of the plant.

The slurry is pumped from the mixers, as already described, or, in the case of the dry process, the powder is fed into the top end of the kiln, through which it gradually descends, first losing its water by evaporation in its passage down 20 feet of the kiln; it then reaches a temperature where all organic matter from the clay and carbonic anhydride (CO_2) is evolved; and descending further, and when within 20 feet of the lower end of the kiln, it reaches a zone of temperature where the chemical combination of the lime with the silicates of alumina takes place, producing Portland cement "clinker."

The hot clinker falls from the end of the kiln into a somewhat similar cylinder, but of slightly smaller dimensions. During its passage through this second revolving cylinder, or "cooler," the heat brought over with the clinker is withdrawn by the passage of cold air through the tube, which becomes heated and is eventually carried upwards by the induced draught of the kiln chimney into the kiln, where it assists combustion.

The rotary kiln produces clinker quite different in appearance from that of the intermittent chamber or continuous shaft kiln. The raw material in its passage down the rotary kiln, as previously described, breaks up into small particles during the process of dehydration and decarbonisation, and presents itself at the clinkering zone in very small particles; so that, in its passage through this zone of fire, the small particles are thoroughly and completely calcined to the centre, leaving no core of half-burnt raw material, as is sometimes the case by the older methods of calcination in large pieces. This perfect calcination is the primary cause of the soundness of the cement produced by this rotary process. The amount of fuel used, and therefore the temperature produced, is entirely under the control of the person operating the kiln; and by means of special apparatus provided he can reduce or increase at will, by altering the speed of rotation of the kiln, the amount of raw material coming towards the firing zone, and also the amount of pulverised coal injected.

The chemical action on the raw material which takes place during its passage through the kiln is as follows: The wet slurry pumped into the upper end of the kiln having parted with all its moisture to the escaping hot gases arising from the combustion of fuel at the lower or calcining end of the kiln, and passing on through a constantly increasing temperature, having parted with all organic matter introduced in conjunction with the clay and all the carbonic anhydride (CO_2) of the carbonate of lime ($CaOCO_2$)—the calcium oxide (CaO) thus formed enters at a temperature of about 2500° to 2800° F. into chemical combination with the silica and alumina of the clay, resulting in a clinker or semi-vitrified basic compound consisting chiefly of tricalcic silicate ($3CaOSiO_2$) and dicalcic aluminate ($2CaOAl_2O_3$).

The proportion of base (CaO) to acid (SiO_2 and Al_2O_3) should not be greater, for a sound cement, than the ratio represented by the following equation:

$$\frac{CaO}{SiO_2 + Al_2O_3} = 2{\cdot}75$$

and this result is arrived at by the mixing of the raw materials in definite proportions, as already described. This equation is based on the chemical equivalents of the constituents and not on percentages, and the method of calculation will be explained under the heading of "Testing—Chemical Composition."

An important improvement, brought about by the rotary process, is the elimination of the fuel ash from the cement clinker. In the older processes the ash from the coke and coal used for calcination must necessarily remain intermixed with the clinker in the kiln from which it cannot be removed; whereas in the rotary process the fine ash derived from the coal is carried away out of the kiln, and does not contaminate the clinker.

The third and final process of manufacture is, like the first, entirely of a mechanical nature. The clinker, as produced by calcination in small pieces, is an absolutely inert material, and no chemical combination with water can take place until the clinker has been reduced by some mechanical means to the condition of a fine powder. This is a very important feature in the manufacture, as it is well known that the chemical action of the cement when subsequently gauged with water is in direct proportion to the fineness of the particles; the smaller the particles the greater the chemical activity, and, therefore, the greater the cementitious value as a material of construction. For this reason the high-class, finely-ground cements on the market are frequently much more economical in use owing to increased covering power, notwithstanding the higher price which is demanded for them.

The reduction to powder of the cement clinker is obtained by means of several classes of machinery, all of a heavy and powerful kind, necessitated by the extreme hardness and refractory nature of the material pulverised.

The method of grinding with millstones has been superseded by many kinds of modern machinery, such as mills of the vertical and horizontal edge-runner type; but the class of machinery mostly used for very fine grinding is represented by the revolving tube system containing steel balls and flint pebbles, the mill containing the steel balls being described as the "ball mill," and the latter with pebbles as the "tube mill." The ball mill, as the preparatory grinder, consists of a revolving cylindrical chamber, the circumferential ends being set at an angle to the circumference, forming a series of steps as the mill revolves. The steel plates forming these ends are perforated, and as the mill revolves with a charge of two to three tons of steel balls rolling on the bottom and falling from step to step, the cement introduced is crushed by the rolling and falling action of the balls to a coarse powder, in which condition it passes through the perforations in the plates and falls on to a series of sieves; the powder fine enough to pass through these sieves constitutes the output of the mill, the coarser particles rejected by the sieves returning automatically beneath the steps, as the mill rotates, into the interior of the mill for further reduction.

The material from this mill is then introduced into a finishing mill or tube mill—a plain revolving cylinder, about 26 feet long and 5 feet diameter, carrying a charge of round flint pebbles, sufficient to about half fill the mill. As this mill revolves, the cement (in a coarsely ground state as delivered from the ball mill) is crushed between the large mass of rolling stones, and finally leaves the mill after passing from one end to the other, during the whole time subject to attrition between the stones themselves and between the stones and the interior steel lining of the mills.

It will be understood that this is a very costly part of the manufacturing process, the cost of grinding being in direct ratio to the fineness; the finer the powder and, therefore, the more valuable the article, the greater the cost to the manufacturer. The most modern practice in this department has led to the reduction of the clinker to such extreme fineness that all passes through a 50-mesh sieve, 98 per cent. through a 76-mesh sieve, 95 per cent. through a 100-mesh sieve, and from 80 to 85 per cent. through a 180-mesh sieve—the sieves mentioned corresponding to 2500, 5776, 10,000 and 32,400 holes per square inch respectively.

It is at this point of the manufacture that the regulation of the setting time of the cement is effected. A thoroughly well made and finely ground Portland cement is always, when first ground, very quick setting. The more thorough the amalgamation of the raw materials, the more perfect the calcination, and the finer the grinding, the greater the chemical activity of the cement produced when mixed with water, and therefore the quicker the set.

Except for work under water a very quick-setting cement is not desirable, and therefore it is necessary for the manufacturer to neutralise the initial setting of the cement by one or other of the recognised methods. Hitherto this has been done by the addition of various small percentages of gypsum ($CaOSO_3$), but as some engineers have an objection to an admixture of this material, the manufacturer was left to seek some other means of attaining the same object.

A new and very effective system, which has been in use now for some time, consists of subjecting the cement in the final stage of grinding to a moist atmosphere. This is done by injecting into the tube mill already described a quantity of steam, regulated at will, which keeps moist the atmosphere in the enclosed mill, so that as the mill revolves, carrying up and rolling over the stones and cement therein, every particle of the latter is subjected to a continuous and repeated process of superficial hydration, eventually leaving the mill in the finished condition, each molecule of cement equally treated. The process is one of great simplicity, and follows quite natural lines. It is well known that a quick-setting cement, if allowed to become aërated by exposure to the atmosphere, becomes slow setting, and that in proportion to the period of aëration, and also improves in soundness by the neutralisation of any particles of free lime present through the absorption of water and carbonic anhydride (CO_2) from the atmosphere. This action is very imperfect, however, when cement is stored in bulk, and can only be in a measure successfully accomplished by continually turning over the cement and exposing fresh surfaces for aëration.

The new system was perfected to overcome these difficulties, and it will be readily understood that the amount of hydration or aëration to which each atom or particle of cement is subjected under the new process during a period of one or two hours in the moist atmosphere of the rolling tube mill is much more perfect than in the case when cement is stored in bulk, and depends for its aëration upon absorption from the atmosphere.

It is not generally known that the free or loosely combined lime in cement will not absorb carbonic anhydride from the atmosphere until it has first taken up moisture and become converted into the hydrate, in which condition it is free to absorb carbonic anhydride from the air, being then converted into inert calcium carbonate.

The effect of the hydration process is first to hydrate any trace of free lime present, and, secondly, to hydrate the loosely chemically combined aluminates of lime, to which latter are attributed the quick initial setting properties of the cement.

The system permits of such minute regulation, depending on the amount of steam injected, that the setting time of the cement being produced can be permanently regulated to comply with the requirements of any specification, the total maximum absorption, even for a slow-setting cement, being less than 1 per cent.

Having passed this final stage of the manufacturing process, the cement is delivered to the warehouse, where it remains until the mechanical heat due to the friction of grinding is eliminated, when the cement is ready for immediate use.

The time at disposal will not admit of a more lengthy description of the three main processes, but from what has been said it will be seen what strides have been made during recent years in placing the manufacture of Portland cement upon a thoroughly scientific basis. Sufficient has been said, however, to enable a comprehensive view to be taken of the various tests to which the cement has to be submitted in the hands of the consumer.

TESTING OF CEMENT.

Chemical Composition.—The chemistry of Portland cement has been and still remains a very abstruse subject. A considerable amount of research has been made from time to time by various chemists, who have thereby thrown some light on the chemistry of a very complex subject; but there yet remains a wide field of research for the scientist and manufacturer before the whole truth will be known.

The following shows the chemical composition typical of the bulk of cements in use, the sample being taken when fresh ground.

ANALYSIS.

Silica (SiO_2)	22·00
Insoluble residue (sand and insoluble silicates) ..	0·75
Alumina (Al_2O_3)	7·60
Ferric oxide (Fe_2O_3)..	3·55
Lime (CaO)..	61·90
Magnesia (MgO)	1·25
Sulphuric anhydride (SO_3)	1·50
Carbonic anhydride (CO_2)	0·25
Water (H_2O)	0·75
Potash (K_2O) Soda (Na_2O) } and loss	0·45
	100·00

The percentage amounts of the various ingredients will of course be somewhat changed if such cement is subjected to prolonged aëration, when the amounts of carbonic anhydride and water will be found to have much increased by absorption from the atmosphere, with a consequent diminution in the percentage quantities of the other ingredients. For this reason, in cases where the percentage of lime present is fixed by specification, the amount found on analysis should be considered absolutely in conjunction with the amount of matter volatile on ignition, i.e. the water and carbonic anhydride; otherwise, it will be clear that an erroneous opinion may easily be formed leading to a mistaken decision as to the quality of the cement.

It is advisable, where an analysis is specified for any cement, that the sample should be taken, if at the works, as soon as possible after the cement is ground, or, if after delivery to the consumer, immediately on arrival; and in either case, the sample should, when taken, be placed in an hermetically sealed receptacle, such as a glass-stoppered bottle, and thus kept free from exposure to the atmosphere till the analysis is made. Under those conditions the original composition of the cement remains unchanged. Unless such precautions are taken, no reliance whatever can be placed on the results of the analysis as representing the composition of the bulk from which the sample was drawn.

It will be foreign to the matter before us to go into the question of methods of analysis, as such matters are not dealt with by the engineer, the same being delegated to some expert fully acquainted with the proper methods, and whose decision is generally acted upon by the consumer.

For many years the maximum amount of lime permitted by the specifications was 62 per cent.; but since the many improvements both in the amalgamation of the raw materials and the more perfect calcination, a large percentage is advisable, and in cases, as in the rotary process, where the clinker is not contaminated with the ash from the kiln, the percentage of lime can be and is beneficially increased up to 64 per cent. in the finished cement. As a matter of fact, 64 per cent. of lime is about the usual percentage in all cement clinker, even when manufactured by the older processes; but during the calcination, the ash (chiefly silicates of alumina) from the coke or coal becomes mechanically mixed with the clinker when drawn, and cannot be separated, and is ground together, reducing the relative percentage of lime in the finished cement in direct proportion to the amount of silicates of alumina, etc., or ash picked up from the fuel, which in actual practice reduces the percentage of lime from the neighbourhood of 64 to 61 per cent., the approximate amount found on analysis in most cements.

In dealing with this point when compiling a specification for cement, the Engineering Standards Committee decided not to fix any definite percentage of lime, regardless of the other ingredients, as has formerly been the custom, but rather to stipulate that this base (lime) should correspond chemically with the percentage of acid constituents (i.e. silica and alumina found to be present in the cement), the ratio of one to the other being represented by the following equation given in the standard specification, which reads, "The proportion of lime to silica and alumina shall not be greater than the ratio represented by

$$\frac{CaO}{SiO_2 + Al_2O_3} = 2{\cdot}75.$$

This equation is based on the molecular weight of the constituents and not on the percentages, and in order to make this method of calculation quite clear, let us work out the equation on the basis of the analysis of cement just given, and see if such composition falls under the maximum limit of the specification.

Converting the chemical symbols in this instance into words, we have the following:—

$$\frac{\text{lime}}{\text{silica} + \text{alumina}} = 2 \cdot 75.$$

The atomic weight of an element is that weight which is the greatest common divisor of the various weights of that element occurring in the molecules of its compounds, the atomic weight of hydrogen being taken as unity.

CaO. The atomic weight of calcium being 40 and that of oxygen 16, and as in lime (CaO) we have one atom of calcium combined with one atom of oxygen, we have a compound having molecular weight of 56. Dividing 61·9, the percentage of lime present in the cement under discussion, by the molecular weight of lime, i.e. 56, we have—

56) 61·9 (11·05.

SiO_2. The atomic weight of silicon being 28·2 and that of oxygen 16, and as in silica we have two atoms of oxygen combined with one atom of silicon, we have a compound with a sum of atomic weights = 60·2. Dividing 22, the percentage of silica present in this cement, by the molecular weight of silica, i.e. 60·2, we have—

60·2) 22·00 (0·366.

Al_2O_3. Atomic weight of aluminium being 27 and that of oxygen 16, and as in alumina we have two atoms of aluminium combined with three atoms of oxygen, we have a compound with a sum of atomic weights of 102, i.e. $27 \times 2 + 16 \times 3 = 102$. Dividing 7·6, the percentage of alumina present in the cement, by the molecular weight of same, i.e. 102, we have—

102) 7·600 (0·0745.

We now have the data for coverting the chemical symbols of the equation into figures as follows:—

$$\frac{1 \cdot 105}{0 \cdot 366 + 0 \cdot 0745} = \frac{1 \cdot 105}{0 \cdot 441} = 2 \cdot 505$$

a figure well within the limits allowed in the new standard specification for cement.

The clinker manufactured by the rotary process, as already described, is practically free from an admixture of fuel ash; and, consequently, although manufactured from the raw material of the same composition as used by the older processes, the actual lime present, the whole of which is chemically combined, is presumably, though not actually, higher than when burned by the older processes, in consequence of the absence of ash mechanically mixed with the old process clinker. No decision, however, can be arrived at as to the quality of cement merely on a chemical analysis; but the data thus obtained is extremely useful in conjunction with results of other tests to be described.

Fineness of Grinding.—As already described, it is customary with a high class of Portland cement to grind to very great fineness as compared with comparatively recent practice, when a cement containing 15 per cent. residue on a 50-mesh sieve (2500 meshes per square inch) was quite common and considered fine ground.

In ordinary practice of to-day the cement is ground so that the whole passes a 50-mesh sieve, as just mentioned, and leaves residue as follows:—

50 (2,500 per square inch)	trace	per cent. residue.
76 (5,776 " ")	1 to 2	" "
100 (10,000 " ")	3 to 5	" "
180 (32,400 " ")	15 to 20	" "

In making this test, which is purely a mechanical one, care must be taken first to see that the sieve used is made of correct standard wire. It will be readily understood, especially in connection with the very fine sieves, such as the 100 and 180, that the diameter of the wire with which the sieve is woven, has an important bearing on the size of the hole: the larger the wire the smaller the hole. If this is not taken into account it will be seen, for instance, that the 100-mesh sieve might really be a finer sieve than the 180 by reason of the larger wire leaving less relative space for the passage of the cement in the 100 than in the 180. The standard usually adopted is that the diameter of the wire for each different sieve shall in each case be equal to half the diameter of the hole—thus for the

76-mesh sieve the diameter of the wire will be 0·0044 inch, corresponding to a total wire width per inch of 0·3344 inch (76 × 0·0044), or one-third of the space—thus each hole with this wire will be twice the width of the latter.

For the 100 (10,000 holes) sieve, diameter of wire 0·0032 (100 × 0·0032), total width of wire 0·32 inch, as nearly as can be one-third.

For the 180 (32,400 holes), diameter of wire 0·0018 inch (180 × 0·0018), total width of wire 0·324, again as nearly as possible, one-third.

Sieves of these standards are readily obtainable.

Having a sieve of the correct standard, great care should be taken not to lose any of the residue during shaking, and the operation of shaking should be continued, especially with the finer sieves, until no more residue is coming through, which can be easily seen by sifting over a piece of white paper. The residue is then weighed—not the flour which has passed through, which latter is liable to loss during the operation of sifting.

By continual use, especially if kept in a damp place, the mesh of the wire is likely to become choked with fine cement; more especially is this the case with the finer sieves, in which case, of course, the results are absolutely misleading and incorrect.

Sieves can be cleaned by washing in very dilute hydrochloric acid and afterwards with clean fresh water, and then thoroughly dried.

Most of the disputes from time to time on the question of fineness arise from one or other of these causes, and if the conditions mentioned were followed much friction would be saved.

Another method of determining the fineness of cement is by means of an apparatus known as the flourometer. With this apparatus air is blown under a constant pressure through a known weight of cement. The process, however, is somewhat lengthy and tedious, and the results are also variable if the pressure is not constant and uniform, in the same way that results of sifting are variable when care is not taken to use standard wire meshes.

Specific Gravity.—This test has superseded the "weight per bushel," and is a much more reliable test than the latter. It is not affected by the fineness of grinding, which destroys entirely the value of the "weight per bushel" test. This test is applied as a measure of the calcination to which the cement has been subjected, as should there be any considerable proportion of underburnt or lightly combined clinker present in the cement, which would be likely to cause unsoundness, the specific gravity would fall below 3·125, which is taken approximately as the standard for well-burnt cement.

This test is also affected, as is the chemical analysis, by exposure to the atmosphere, and in every case the conditions of sampling for this test, as for that for analysis previously described, should be enforced.

As is well known, the specific gravity of a substance denotes the ratio of the weight of any volume of that substance, as compared to an equal volume of pure water at its point of maximum density, 4° C. or 39°·9 F.

Well-burned fresh cement is 3·125 times heavier than water; but it will be readily understood that if the cement is allowed to combine with varying proportions of water and carbonic anhydride before the specific gravity test is made, there will be a reduction in the relative weight or specific gravity in direct proportion to the amount of absorption. Samples, therefore, should be kept in hermetically sealed vessels out of contact with the air.

This test, when required, is usually carried out by the expert engaged to examine and report on the cement, who is of course fully aware of all the conditions under which the test has to be carried out.

When such is not the case, and the test is made at the works, great care must be taken to get reliable results. The system consists in measuring the volume of a given weight of cement in some liquid not affecting the cement. Petroleum free from water is the most convenient medium; but care must be taken to record carefully the temperature of the petroleum and apparatus at the commencement of the operation, and to see that the same temperature is restored before reading the displacement caused by the introduction of the cement. If this is not done, the volume of the cement added to the petroleum will be recorded *plus* the expansion of the petroleum, or *vice versâ*.

Setting Time.—The new standard specification provides for cement of various setting times, and describes these as follows:—

"There shall be three distinct gradations of setting time, which shall be designated as 'Quick,' 'Medium,' and 'Slow.'

> "*Quick.*—The setting time shall be not less than ten minutes, nor more than thirty minutes.
>
> "*Medium.*—The setting time shall be not less than half-an-hour, nor more than two hours.
>
> "*Slow.*—The setting time shall be not less than two hours, nor more than five hours."

Here, again, the cement supplied by a manufacturer to a required setting time may vary considerably in its setting characteristics, in accordance with the amount of aëration to which the sample is subjected; and this unavoidable variation, due to atmospheric causes, is a fruitful source of trade disputes. The cement should, as far as possible, be tested as received.

The method for testing the setting time most in favour is that of the use of a weighted "needle," having a point $\frac{1}{16}$-inch square and weighing in all 2½ lb. The cement is not considered set so long as an appreciable impression is made when the needle is carefully applied to the surface of the pat.

In gauging the pat for this test, sufficient water should be used to make a plastic mass, but care must be taken not to use an excess of water, which would result in a scum on the surface of the pat, which would make observation of the real impressions difficult and lead to divergent results.

Many cements, especially those of a slow-setting character, will continue to show faint impressions upon application of the needle long after the actual "setting" has taken place, which will continue until the superficial hardening of the pat prevents any further marking.

In cements of this description experience only can guide one in fixing the point when setting is complete and hardening in progress.

The temperature and humidity of the surrounding atmosphere also plays a not inconsiderable part in the action of the setting of cement. A hot dry atmosphere will tend to more rapid setting, whereas very low temperature will seriously retard, if not entirely prevent, the setting of cement. As far as possible a normal temperature of 62° F. and a moist atmosphere should be maintained in the laboratory. Pats should always be made on glass or some other non-absorbent material, and kept in such a position that undue evaporation of the gauging water is prevented.

Very slow setting cements frequently show contraction cracks while setting from this cause, the water being evaporated before the chemical action by crystallisation is complete, with consequent shrinkage. There is no difficulty, however, in distinguishing between a contraction and an expansion crack. The former, however, is frequently taken for the latter, causing much consternation and unnecessary trouble and anxiety to the consumer and annoyance to the manufacturer, who, having supplied what has been required of him, cannot control the forces of nature. In testing slow-setting cements for setting time it is always advisable to take special precautions against evaporation; the pats, when gauged, should be covered or placed in some receptacle in which the atmosphere can be kept moist until the setting is complete.

The briquettes shall bear on the average not less than the following tensile stresses before breaking:—

7 days after gauging	400 lb. per sq. inch of section.
28 " "	500 " "

The increase from 7 to 28 days shall not be less than

25 per cent. when the 7-day test falls between 400 lb. and 450 lb. per sq. inch section.
20 per cent. when the 7-day test falls between 450 lb. and 500 lb. per sq. inch section.
15 per cent. when the 7-day test falls between 500 lb. and 550 lb. per sq. inch section.
10 per cent. when the 7-day test is 550 lb. per sq. inch or upwards.

Tensile Strength.—Much has been written from time to time concerning the methods of conducting this test for mechanical strength, but time will not permit of going very closely over the ground.

In the hands of the expert there is little difficulty in conducting this test, but in the hands of the novice the reputation of the manufactured article is everlastingly trembling in the balance.

Care should be taken that moulds are thoroughly clean and free from any excess of lubrication.

Neat cement for this test should always be taken in weighed quantities, and the water, thoroughly clean, always measured, so that a record is always available concerning the briquette.

Briquettes should always be made singly, especially when the cement is quick setting. The custom of gauging enough cement at one time to fill several moulds is very objectionable and frequently leads to most unreliable results, the first briquette and perhaps the second, turn out all right, but the remainder fall short of the required strength, because, forsooth, the cement had commenced to set before the briquettes were finished. The setting of the cement having been thus broken up, the chemical action due to setting is never again thoroughly complete. Again, it is objectionable to use nests of moulds, say four or six, as is frequently done, even if the briquettes are gauged singly, as with a moderately quick setting cement in the hands of the inexperienced the packing of the last briquette disturbs by vibration the setting of the first of the series, which may have already commenced to set.

Each mould should be quite separate and distinct, and, when filled, placed where no vibration can disturb it.

It is only slow-setting cements that escape failure under these two headings in the hands of the inexperienced.

All briquettes, whether neat or with sand, when first gauged should remain in the mould for twenty-four hours, and be kept in a damp atmosphere at normal temperatures during the whole of that period. They are then carefully removed for immersion in water, in accordance with the requirements of the specification.

The quantity of water to be used for gauging should be that quantity which will produce a plastic condition when the cement is packed in the mould; but care should be taken that the cement is kept in the form of a damp powder until packed in the mould, when slight tapping will so consolidate it as to render it plastic. If the cement is trowelled into a plastic mass before being placed in the mould, the air-bubbles in the mixture cannot be excluded and a briquette full of air spaces will result. If packed into a mould, however, in the form of a damp powder, the air escapes before plasticity is reached, and a solid and homogeneous briquette is the result.

The quantity of water ranges from 18 per cent. to 22 per cent. in accordance with the fineness and setting properties of the cement under test; and a trial should be made with one or two briquettes to discover the most suitable quantity of water, which, if not satisfactory, should not be included in the series from which the test records are to be made.

For "sand tests" none but the Standard Leighton Buzzard testing sand should be used. This material is readily obtainable, and is of such fineness that all passes a 20^2 mesh sieve (400 holes per square inch) and is retained on a 30^2 mesh sieve (900 holes per square inch). Before use, this sand should be tested as to its behaviour on sieves of this description, so that any coarse particles or fine powder may be eliminated.

All the precautions recommended for the making of neat briquettes apply equally when making briquettes containing three parts or any other number of parts of sand to one part of cement. The quantities should always be taken by weight and not by measure. The percentage of water most suitable ranges from 8 to 10 per cent. of the weight of the dry mixture.

The briquettes during immersion should be kept as nearly as possible at an even temperature; great extremes should be avoided.

Briquettes should be broken at the due dates, immediately after being taken from the water, and should not be left about to dry before being tested.

Whatever form of breaking machine is used, care should be taken that the briquette is placed evenly and squarely in the clips, so that when the strain is applied, the pull is even on all parts of the square inch section, and no side strains are set up, the latter resulting in defective fracture and irregular results.

It is important also that the strain should be applied evenly, and at a uniform rate. The standard usually adopted provides for the application of the strain at the rate of 400 lb. per minute —very irregular results will be obtained if care is not taken in this particular.

An average of results of five briquettes, both in the case of neat and sand tests, are usually sufficient for conclusions to be arrived at as to tensile strength. The results, however, of any apparently faulty briquette giving exceptionally low results should be eliminated, as it is evident the fault must be due to manipulation, as whatever strain the average number of briquettes of the series may be capable of standing, all should do under like conditions.

Soundness.—A great deal has been written on this subject, and much useful information is obtainable from works of reference treating the subject of Portland cement. The test is of perhaps more importance than any other test to which cement is subjected.

Portland cement used as a constructive material takes a long period of time to arrive at its maximum strength, and sometimes long intervals elapse after use before defects, if any, begin to show themselves.

The tests for soundness consist chiefly of exposing a set cement to various high temperatures in water, in order to hasten the ultimate results likely to be obtained under various climatic conditions.

Many tests of a more or less stringent character have been introduced; the most severe being the boiling test. There are various methods of carrying out this test, but the most rational and severe is that known as the Le Chatelier method.

The apparatus for conducting this test consists of a small split cylinder of spring brass or other suitable metal, 30 millimetres internal diameter and 30 millimetres high, so arranged that the expansion of the cube of cement, when boiled, can be measured.

This is the most stringent test for soundness in use, and has an advantage over all other tests, which only record expansion without any means of measuring the amount of same. It errs, however, on the side of severity, as thousands of tons of cement manufactured in the past—which have resulted in splendid work—and much cement that may be manufactured in the future, which may also do good work, would fail to pass this most stringent test.

MODERN APPLICATION.

The great success that attended the early efforts to construct with Portland cement concrete reinforced with iron or steel, has led in the last few years to great advances in this mode of construction.

These structures combine lightness, graceful lines and fire-resisting qualities, as has been demonstrated often in actual conflagrations, as in the great fire at Antwerp, where it was further shown that half-an-inch to an inch of concrete surrounding the steel bars was sufficient to prevent any ill effects.

The materials, concrete and steel, are scientifically combined so that the tensional strains are taken by the steel bars and the compressional strains by the concrete, the tension and compression members of a beam being connected by steel stirrups suitably distributed along the length of the beam, making a solid and compact girder capable of bearing the heaviest loads.

Ferro-concrete has been rightly described as a new material. As an example of this, it may be mentioned that ferro-concrete beams show under test ten times the elongation without showing any cracks or sign of disintegration that a similar beam of concrete only will give.

Buildings constructed on this system show great absence of vibration where high-speed machinery is in use, owing to the monolithic nature of the structure, in which every part is solidly bonded to every other part, from foundations to roof, without a single joint, bolted, riveted or otherwise. This fact also makes these buildings very sanitary, as no rodents or microbes can attack the material or find harbourage in it.

The nature of the work entailed is so essentially simple that, beyond a few leading hands, only unskilled labour is required to carry out the largest works, and the impermeable nature of fine, well-rammed Portland cement concrete makes this material an excellent non-conductor, ensuring an equable temperature in ferro-concrete buildings.

From the first it was evident that the ordinary laws, formulas and methods of calculation used for ordinary materials could not be applied in structures composed of such heterogeneous substances as concrete and steel. However, numerous attempts were made to use ordinary methods in making due allowance for the difference between the coefficients of elasticity of the two materials. Up to now these attempts seem to have been abortive.

In practice these structures are usually tested within a very few weeks after completion, with loads 50 per cent. in excess of the calculated load. The deflection is measured—which, in the case of floors, rarely exceeds one-thousandth part of the span under test; and so reliable has this method of construction become, that a maximum deflection of one six-hundredth part is often guaranteed; and it is expected, when the load has been removed, that the floor, owing to the elasticity of ferro-concrete, will regain its former level, or, at any rate, that the deflection, if any, will be quite inappreciable. And how could it be otherwise, when it is considered that any stress applied to any part of a well-made ferro-concrete floor affects not merely the part under load but also a very large area of the floor surrounding the part under observation ? This is due to the absolute monolithism of the work.

All kinds of work have been carried out in this material—a few examples of which will be shown you directly on the screen; but it is well to mention here one of the most startling applications of ferro-concrete, namely, piles. Many thousands of these have been driven with the utmost success into all natures of ground by the ordinary piling engines used for timber piles. The piles are calculated as beams, as they have to be lifted in all sorts of positions, and the steel skeletons are calculated and arranged to suit the varying loads to be carried and in accordance with the nature of the ground to be pierced. Lengths up to 70 feet have been driven, and the punishment inflicted with impunity has in some cases been very severe. Recently one of these piles was driven for three whole days with a 30 cwt. monkey, and received no less than 10,972 blows without breaking.

The cost of ferro-concrete piles is somewhat in excess of timber, but the number required is smaller, and the cost of the structure is less than if the timber piles had been adopted.

Where it is desired to erect a structure on bad ground incapable of carrying heavy loads, ferro-concrete is especially suitable, and results in large economies.

The question of the protection afforded to the steel skeleton by the concrete from the action of sea-water has often been demonstrated, and was recently raised again when some old pile heads, which had been cut off in the making of a jetty at Southampton some seven years ago, and which had since lain on the foreshore, alternately covered and uncovered by the tides (four times a day in this instance) were taken up, and the concrete stripped away from the steel bars. Although the protruding ends of the bars had completely rotted, it was found that even only ½ inch under the concrete the bars were as bright as when they left the rolls of the mill.

Experience shows us that oxide of iron cannot exist in contact with concrete, and that rusted bars embedded in concrete, will in the course of a month or so be as bright as new, the rust having been deoxidised and formed into a ferrite of calcium, which forms a protective skin round the bars.

It must also be borne in mind that concrete used in ferro-concrete is different from ordinary concrete both in its composition, in its make, and in the way it is employed. It is composed of materials of small volume (¾ of an inch maximum for the gravel or stone), and the materials used must be clean. The proportions of sand and stone are always adjusted so as to give a concrete quite full; it is used in small quantities at a time and so vigorously rammed that no cavities or porosity are at all possible. Pieces have been repeatedly cut out of work, weighed, immersed a long time in water, then weighed again. The absorption was practically nil. Numerous water-towers have been constructed; the thickness of the walls of the reservoirs rarely exceeds 5 inches; they are perfectly water-tight, and this without the help of any lining such as asphalt.

The adherence of concrete to steel has been questioned sometimes, but the coefficient of adherence has been repeatedly determined. It is approximately 570 lb. per square inch of metal in contact with the concrete. The value is such that it justifies the practice of some ferro-concrete builders who only reckon on concrete to make the junction between the different metallic parts of a structure. As regards the expansion of concrete and steel, their coefficients have been demonstrated to be identical up to the fifth place of decimals; so in practice they may be considered equal.

DISCUSSION.

The PRESIDENT: Now, gentlemen, I wish on your behalf and my own, to move a hearty vote of thanks to Mr. Bamber for his excellent paper. It has been made so much more interesting by the biograph and other pictures shown by the lantern. When those views were exhibited on the screen, I could not help throwing my memory back to the time, some fifteen or sixteen years ago, when I went over some cement works. Then I was very nearly choked with dust, beside being covered from head to foot with the same material, and when I came away I could not help asking myself whether the game was worth the candle. I doubt whether, if I had been asked to go over the works again in a month's time, I would have accepted the invitation. To-night we have seen all the processes of manufacture in comfort and without being covered with dust. You will agree with me that a very hearty vote of thanks is due to Mr. Bamber for writing the paper and for coming here to read and illustrate it. I should like to incorporate with that a vote of thanks to M. De Vesian for giving us the illustrations of examples of ferro-concrete work. Curiously enough on Wednesday last I visited Liverpool and saw the Burlington Steeet bridge, which has been shown to us to-night on the screen. That bridge has been put up under the supervision of Mr. Brodie, the city engineer of Liverpool. My object in going there was to try and induce my county council to construct a bridge of similar material across the Severn. The Burlington Street bridge at Liverpool was the nearest bridge of the kind to Shropshire, and as it was in course of construction, we were invited to go and look at it. One half of the bridge was open to traffic, and heavy vehicles were passing over it, while the other half was being constructed. It is not an arch but a girder bridge. I think you have had a sufficient demonstration to-night that ferro-concrete is a useful as well as a new material for construction work. We have in combination two very strong materials—steel and cement. We know that under the new process of cement manufacture—the rotary process—we get the very best results from the cement. We know also what steel will do; and in the combination of the two we get a material which will open a new era in construction work—the ferro-concrete era. We have seen that large buildings, grain silos, manufactories, and other buildings, where heavy merchandise has to be stored, can be erected of this material without any disaster. We have also bridges of large span which have been erected in ferro-concrete on the Continent. We have not any experience of such examples of construction, I believe, in this country; the bridge with the widest span, constructed of this material in this country, is 45 feet. But I believe before long, we shall have bridges of much larger span. I ask you to join with me in giving a hearty vote of thanks to these gentlemen for the trouble they have been to in presenting information to the Association.

The vote having been accorded with acclamation,

Mr. H. K. G. **Bamber**, in reply, said: I thank you for the hearty vote of thanks you have given to M. De Vesian and myself. It has been a great pleasure to me to come here and tell you all about this very interesting subject. To me, personally, the most interesting part of this evening's meeting has been the description of ferro-concrete work by M. De Vesian. Portland cement is a very familiar subject with me; construction in ferro-concrete is a new subject and a very interesting one. We are very conservative in England, and it is a pity we have allowed the foreigner to get so far ahead of us in this new form of construction. It is only necessary to convince you that you have an economical kind of material, and one which shows greater stability than the old form of construction, for you to sweep away the whole of the difficulties which exist with respect to this form of construction. I believe at present these difficulties are considerable, under certain by-laws, but it only needs your help to get them swept away.

MIDLAND DISTRICT MEETING AT MARKET HARBOROUGH.

May 13, 1905.

Held at the District Council Offices, Market Harborough.

A. T. DAVIS, M. INST. C.E., PRESIDENT, *in the Chair.*

THE Chairman, Mr. J. L. Douglass, and Members of the District Council received the Members and offered them a hearty welcome to the town.

The President, on behalf of the Association, thanked the Chairman for the cordial welcome he had given them.

Mr. H. Richardson, Honorary Secretary, read the minutes of the last District Meeting at Birmingham, which were confirmed.

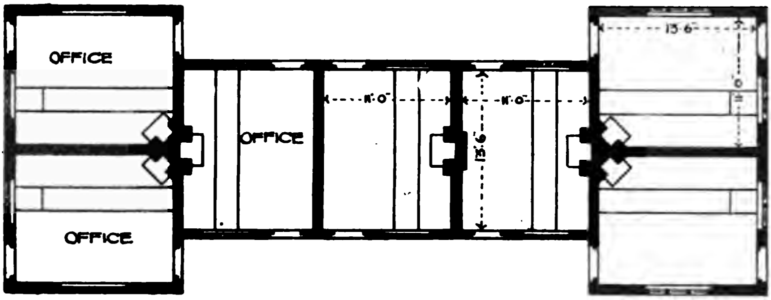
The following papers were then read and discussed.

NEW CATTLE MARKET AT MARKET HARBOROUGH.

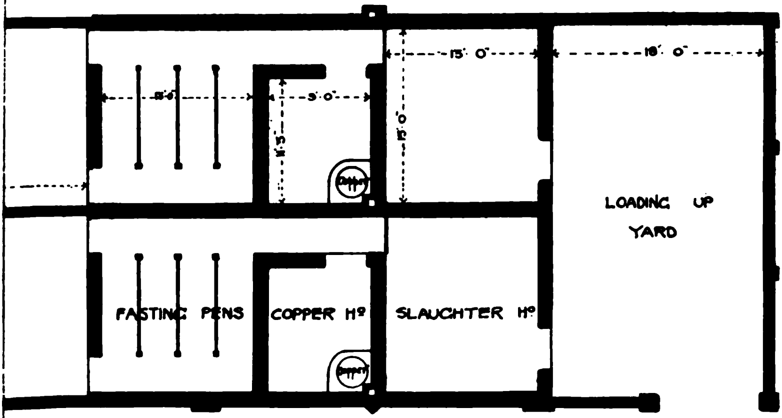
BY HERBERT G. COALES, ASSOC. M. INST. C.E., F.S.I.

IT must be evident to anyone that the first name in Market Harborough points to its having been looked upon in the past as an important market town. In 1219, in the reign of Henry III., we find an entry in the Close Rolls referring to Harborough Market; and another in 1221, wherein the King allows Harborough Market to be changed from Monday to Tuesday, on which day it is still held. From the town documents of the

BOROUGH CATTLE MARKET—PLATE I.



PLAN OF AUCTIONEERS' OFFICES.



PLAN OF SLAUGHTER-HOUSES.

To face p. 192.

time of Henry VI., we learn that Harborough once had a market cross, but it was taken down in 1615, for which the townsman paid the workmen 1*s*. 8*d*., and 4*d*. for carrying the cross stones to the "Ram"-yard.

OLD MARKET PLACE.

Previous to the building of the new market in 1903, the markets were held in the streets of the town from time immemorial; and, until a recent date, what is now known as "The Square" was called the "Sheep Market," because here were penned sheep, pigs, and calves. The high street was used as a pitch for cattle. The condition of Market Harborough in the past on a market day may be imagined, and more especially on a fair day, when perhaps upwards of 2000 beasts would be in possession. It had been the privilege of the Lords of the Manor to take tolls on all animals coming into the town on a market day, but in 1874, a gentleman freed the owners of the cattle from the obligation, by the payment of a lump sum to the Lord of the Manor. The exaction of the tolls had in past times carried with it certain duties on the part of the lord, including the protection of the stock and persons using the market, and probably the cleansing of the streets. But these duties gradually disappeared, and the public authorities had the expense thrown upon them.

Market Harborough is situate in the rich feeding land of the Welland Valley. A ploughed field is the exception, and as there is so much grass-land on which beasts may be grazed and fattened, it is not surprising that the establishment of a market became an obvious necessity. Two very important and well attended cattle fairs are held annually, one in October and the other in April, the average number of beasts pitched being from 1800 to 2000 at each.

NEW MARKET PLACE.

Such then were the conditions when in August, 1900, a poll of the inhabitants was taken, as to whether the Council should or should not purchase the market rights, and establish a proper up-to-date market place, other than in the streets of the town.

The poll resulted in 858 voting for the purchase, and 739 against. Negotiations were entered into with Lord Barnard, the present Lord of the Manor, and the market rights were purchased for 2455*l.*, and 12 acres of grass land in a central and accessible position, at the very moderate price of under 300*l.* per acre, or a total of 5967*l.* for the market rights and the land.

A plot of building land was also acquired on the St. Mary's Road for 600*l.*, by which the proposed new market could be connected by a bridge with the main thoroughfare leading to the joint railway station, should it in the future be found desirable so to do. In addition Lord Barnard presented the Fair tolls to the town.

The site is served by three roads, Springfield Street on the south, Kettering Road on the east, and Northampton Road for a short length on the west. The northern boundary is, for the most part, the river Welland. The distance from the centre of the town is 200 yards, and 700 yards from the joint station of the Midland and London and North-Western Railways.

The Author prepared preliminary sketch-plans for laying out the intended market, and, with a deputation consisting of Messrs. Hopton, Douglass, Flint, and Clark (Members of the Council), visited various markets with the object of benefiting by the experience of other towns. A report was submitted to and adopted by the Council recommending the accommodation to be made, and appointing the Author engineer, upon mutually agreeable terms. The Author had the co-operation of his partner, Mr. H. Winter Johnson, F.R.I.B.A., throughout the scheme, but more especially in respect to the architectural portion of the work. It is hoped the following description of the works may be interesting to the Members of the Association.

General Arrangement.—The 6 acres of land nearest the town are laid out for the market proper, the remaining 6 acres being used for open lairages for the stock attending the market.

There are three entrances: the principal one, and the nearest to the town, being from the Northampton Road, whereat sheep, calves and pigs are admitted; the other two entrances are both from Springfield Street, for the use of beasts and horses.

The shedding, placed on the north side of the site, affords as much shelter as possible for the market from cold winds.

Accommodation.—The following pen accommodation is provided:—

1200 Cattle to be sold privately.	**1720 Sheep to be sold by auction.**
400 Cattle to be sold by auction.	**300 Pigs in shed.**
440 Sheep to be sold privately.	**162 Calves in shed.**

In addition there is a shed for poultry, and a space set apart for a show ground for horses; also a pitch for agricultural implements, hay, roots, etc.

A good deal more stock can be accommodated than indicated above during fairs, or on emergency, on the roads and open spaces of the market.

Accommodation for Auctioneers.—There are four sale rings for cattle, designed with a view to the convenience of buyers, who can readily see the animals as they are passed along to the selling ring, without incurring any danger of injury from them. The iron fencing and paving are as described for the other cattle pens, with the addition of gates and gullies as required.

A plank is fixed along the centre of the sheep pens, above the fencing, from which the auctioneer sells.

Auctioneers' offices are built in the centre of the market between the sheep and the beast pens, and each is let on lease at 10*l.* per annum.

Levels.—The northern and eastern parts of the land, being liable to floods, were made up to above flood level with surplus earth excavated from the southern and western parts. The fields had originally a fall of 5 feet from the south-west to the north-east corners: now the fall is 2 feet, or a gentle gradient of 1 in 335.

In addition to bringing the surface of the market above flood-level, the river on the northern boundary was widened its whole length, and the bends piled with old railway sleepers.

Drainage.—All the drains are connected with the town sewers, with a penstock arrangement for turning the water into the river on other than market or cleaning days: the sewage farm having quite enough sewage to filter without the addition of the rainfall from 6 acres of paved surface.

The main drains are 9 inches and 6 inches in diameter, with inspection chambers at frequent intervals. Where there appeared a likelihood of the tree roots getting into the drains, the latter were concreted.

Water Mains.—Two systems of water mains are laid in the market: one, a 3-inch service from the high-pressure town water main in Springfield Street to a fire hydrant near the centre of the market, and from which drinking water is supplied to the refreshment rooms; and the other, a 6-inch low-pressure main with 3-inch branches, from an auxiliary supply, for cleansing the market. Sluice hydrants are placed on the low-pressure mains in suitable positions all over the market for the ready cleansing of its surface. Stoneware drinking troughs are placed in the centres of the roads for providing the cattle with water.

Gas Mains.—3-inch mains are laid through the market from which the buildings are supplied with gas. There are no outside lamps required, the market being over long before dusk.

Roads.—The main roads are 36 and 40 feet in width, and of tar macadam. The foundation is of furnace slag, 8 inches thick, hand pitched and steam rolled. The tar macadam is 4 inches thick, composed of 2-inch broken furnace slag, dried on hot plates, mixed with boiling tar and a little pitch, also steam rolled; and finished with a ½-inch top layer of ⅜-inch granite chippings and boiled tar, well steam rolled. The roads were completed by a slight sprinkling of fine granite chippings. The cost of the roads complete was 3*s*. 3*d*. per square yard.

Two roads are made of ordinary Leicestershire granite macadam 4 inches thick, with an 8-inch slag foundation similar to above. The cost of the macadam roads complete was 2*s*. 7*d*. per square yard. One of these roads is for showing horses on, and the other on which implements, loads of hay, and miscellaneous goods may be pitched.

Trees.—A bank on the western boundary, formed in the process of levelling the site, is planted with shrubs and trees.

Lime trees are planted about 20 yards apart on the centres of the main roads, partly for adornment and partly for providing shade. The trees were purposely planted away from the pens, to prevent the roots from lifting the paving, The trees are protected with specially stout iron guards; and the tar macadam is made good round the trees with 5-inch by 10-inch concrete kerbs.

CONSTRUCTION OF PENS.

Cattle Pens.—The store cattle (chiefly Welsh and Irish) are held up by drovers in open pens, a 12-foot gangway running up the centre of each bay. The pens are 36 feet long and 12 feet deep. The cast-iron posts, placed 6 feet apart, weigh 3½ cwt. each, and are fixed in the ground with Portland cement concrete. The rails are five in number, of 1½-inch solid round bar iron; the lowest is 1 foot 3¼ inches from the ground, and the others 10¼ inches from centre to centre, the top rail being 4 feet 10 inches high. The rails are keyed into the posts with iron keys. The Author used solid bars in preference to tubular as being easier to straighten in case of damage. The cost of the fencing complete, including excavation, concrete and painting, was 1*l.* 2*s.* 3*d.* per yard lineal.

The paving of the pens and gangways is of dressed random granite setts, grouted in cement, on 2-inch bed of granite gravel, with a 6-inch foundation of lime concrete mixed 1 to 6. The cost of the paving complete was 7*s.* 6*d.* per square yard.

The setts give a very good foothold to the cattle: much better than concrete or blue bricks. Dressed random setts are only about ⅔ the cost of dressed setts, and are quite good enough for the purpose.

The cross fall of each pen is 4 inches. A channel is formed on either side of the central gangway, which is 2 inches higher than the channels.

The longitudinal fall of the pens is about 1 in 300, and there are no drains in or under the pens: the channels convey the water to gullies placed in the main roads.

Each single pen will accommodate 18 beasts, allowing 2 feet in width per beast, the space suggested in the model by-laws of the Local Government Board.

Sheep Pens.—The sheep pens are in double rows, all intercommunicating by gates, with a gangway 7 feet 6 inches wide between each block. Each pen is 8 feet 6 inches by 6 feet. The cast-iron posts weigh 100 lb. each, and are concreted in the ground. The rails are four in number, keyed to the posts; the top rail is 1 inch round bar iron, 2 feet 9 inches from the ground; the other rails are ⅞ inch round bar iron, 10½ inches, 9 inches, and 8 inches apart respectively from centre to centre. The cost of the fencing complete, including gates, excavation, concrete and painting, was 12*s.* 7*d.* per yard lineal. The gates are secured with turnover fastenings.

The paving is of Portland cement concrete, mixed on the average thickness of 1 to 3 laid *in situ* 3 inches thick, on a 4-inch bed of broken rubble, with herring-bone grooving in the pens, the gangways being smooth. The cost of the paving complete was 4*s.* per square yard.

The cross fall of each pen is 3 inches. The method of draining is as described for the beast pens.

Each pen will hold twelve sheep, allowing four feet superficial to each sheep.

Covered Pig Pens.—The pig pens are of the same size, and constructed in a similar manner to the sheep pens, but with 5 rails instead of 4 to keep in the small pigs.

The pig shed is 114 feet long by 30 feet wide, 9 feet 3 inches high to wall plate. The roof is tiled, and supported by steel principals on cast iron columns, 11 feet 4 inches apart; and 14-inch common brick back and end walls. A 5-foot north light of W. H. Heywood and Co.'s glazing runs the entire length of the shed, so that an abundance of light is provided.

Covered Calf Pens.—The calf pens are a single row of 8 feet 6 inches by 6 feet; the fencing and paving are similar in every respect to the sheep pens.

The calf shed, is 188 feet long by 18 feet wide, and 9 feet 3 inches high, to the wall-plate; and similar to the pig shed, except that the roof principals are of wood.

Covered Poultry Pens.—The poultry shed, 60 feet long by 18 feet wide, is similar in construction to the calf shed. The building is provided with wooden pens with wire fronts.

REFRESHMENT ROOMS AND CLOCK TOWER.

In the centre of the market is a block of buildings comprising first and second class refreshment-rooms, with cellarage underneath; and upstairs, a kitchen, scullery and larder, over the second class bar, with a dining-room (used at present as a settling-room) over the other bar. A clock tower is carried up at the south-west corner of the block, fitted with a Gillett and Johnston's four-faced clock. At the north-east corner of the block a suite of first and second class lavatories are provided. The arms of the Earls of Harborough are carved on the clock tower, the Council having first obtained permission to use them as the town arms whilst the market was in course of erection. Mr. S. L. Reynolds of Northampton was the carver.

SETTLING ROOM AND CORN EXCHANGE.

Near to the refreshment rooms is a one-storey building 25 feet long by 18 feet wide, used as a settling room by persons not caring to settle on licensed premises. It also answers the purpose of a corn exchange, being provided with merchants' stands.

SUPERINTENDENT'S LODGE AND OFFICE.

A house for the Superintendent, Mr. James Pawsey, is built near the eastern entrance in Springfield Street, with an office for his use attached.

WEIGH-BRIDGE AND OFFICE.

A Pooley's 7-ton weigh-bridge is erected, with a little weigh-office, near the Superintendent's house, fitted with movable railings for cattle-weighing.

ISOLATION PENS.

Isolation pens for cattle and sheep are provided between the river and the calf-shed for the isolation of animals discovered in the market to be infected with contagious disease.

PUBLIC CONVENIENCES.

In addition to the urinals and water-closets provided in the central building, two other blocks of urinals are provided at convenient positions in the market—one near the beast pens to the west, and the other near the sheep pens to the north.

BOUNDARY WALLS.

The boundary walls, abutting on the streets, are of 14-inch brick, with Weldon stone coping and wrought iron unclimbable fencing; total height of brickwork and fence 8 feet.

The specially-designed wrought-iron entrance gates are hung to Weldon stone carved piers.

CONTRACTS.

The work was let in five contracts :

	£	s.	d.
Nos. 1 & 4. Laying out, drainage, road making, and paving, being secured by Mr. Thos. Philbrick of Leicester	8,125	0	3
No. 2. Ironwork, Messrs. S. Russell and Sons of Leicester.	2,965	17	5
No. 3. Buildings, Mr. Thos. Hickman of Market Harborough	6,589	9	10
No. 4A. Concrete paving, Messrs. A. Walker and Son of Pudsey	576	6	2
Additional fencing and water-mains, etc. . . .	524	19	9
Total cost of works . . .	£18,781	13	5

Amongst the sub-contractors The Crittal Manufacturing Co., Ltd., supplied the iron casements used in the buildings ; Messrs. Oates and Green, the lavatory equipment ; and Messrs. W. Miller and Sons, the entrance gates and boundary fencing.

The several works were well and substantially carried out by the various contractors, as the Members will have an opportunity of observing.

The total outlay on the market, including land, purchase of rights, and works, was 25,950*l.*

OPENING.

The market was formally opened on April 14th, 1903, by Mr. J. L. Douglass, the Chairman of the Urban District Council; who, with Mr. Jeffery Clark, the Chairman of the Markets Committee, kindly entertained a numerous company to luncheon at the refreshment rooms on that day.

FUTURE EXTENSIONS.

The market has been designed with a view to future extensions : fenced-in spaces being reserved for additional beast and sheep pens, the provision of which will not in any way disturb the existing roads or arrangements.

FIRST TWO YEARS' WORKING.

The market has been opened just over two years, and the number of animals pitched is as follows:

—	Year ending March 31st.	
	1904	1905
Beasts	20,495	22,504
Horses	518	441
Sheep	23,751	26,730
Calves	1,123	1,134
Pigs	2,360	2,430
Poultry (couples)	1,543	1,601

LIST OF TOLLS LEVIABLE IN THE MARKET.

HORSES.

For every Stallion	1s.
„ any number of Horses, Mares, Geldings, Colts or Fillies, belonging to the same owner, not exceeding six, per head	6d.
„ any number of ditto, exceeding six, per head	4d.
„ every Mule or Ass	3d.

CATTLE.

„ every Bull	6d.
„ every Ox, Cow, Steer, Yearling, or Heifer	3d.
„ every Calf	1d.

SHEEP AND GOATS.

„ every Ram	3d.
„ every Sheep or weaned Lamb, Goat, or weaned Kid	1d.

PIGS.

„ every Sow and her litter or farrow	6d.
„ every Fat Pig	2d.
„ every other Pig	1d.

Auctions.—When such animals or marketable commodities are sold by Auction, tolls double the above amounts shall also be paid in addition to the tolls hereinbefore prescribed.

POULTRY.

For every Couple of Fowls, or of Ducks, and for every Goose or Turkey	1d.

HAY AND STRAW, ETC.

„ every wagon-load of Hay, Straw, or other Agricultural Produce	1s. 6d.
„ every cart-load or less of ditto	9d.

SLAUGHTER-HOUSES.

With a view to the ultimate extinction of unsuitable private slaughter-houses in the town, the Council are building two new slaughter-houses on the market lairages, as a first instalment. The rent of each is 20*l.* per annum. The accommodation provided for each is an open yard 21 feet by 15 feet, 4 fasting pens for cattle, a copper room, 12 feet by 9 feet, and the slaughter-house 15 feet by 13 feet. The latter is lined with white glazed bricks for a height of 5 feet 3 inches. The floor of this, as well as that of the copper room, is of concrete. The other floors are of dressed random sett paving, as described for beast pens for market. The contract amount is 800*l.*, and the builder is Mr. W. W. Brown of Market Harborough.

BRIEF STATISTICS OF MARKET HARBOROUGH.

It is generally considered that Market Harborough has great advantages to offer to manufacturers establishing works here. The railway accommodation is excellent; land can be had at a low price; the local rates are very small compared with other towns; and the working classes are well housed.

As a residential town, or hunting centre, it can boast of an excellent water supply and drainage; a death-rate much below the average; picturesque building sites; ample facilities for sport: including hunting (Pytchley, Fernie's, Woodland Pytchley and Quorn), golf links, and polo ground.

The Council has this year completed a quarter of a century's local self-government.

—	1880	1890	1900	1905
Population	5,300	5,800	7,735	8,700
Rateable Value . . .	£32,211	£37,500	£52,270	£55,929
Area (acres)	4,520	4,520	4,520	4,520
Number of Houses . . .	1,142	1,200	1,682	1,901
Death-rate (per 1,000) . .	20	15·6	12	9·41

RECENT NEW WORKS.

Since the last meeting of the Association at Market Harborough in 1897, the Urban Council has acquired the gas works (Engineer and Manager, Mr. A. T. Harris) at a cost of

49,000*l.*, including reconstruction and new offices. Also a recreation ground, comprising 16 acres, cost 3100*l.*

The Council has taken over the care of the two cemeteries of the district.

The Council has built:

	£
A new cattle market (inclusive of the purchase of the market rights)	25,950
Two slaughter-houses (in course of erection) contract	800
Fire-station	597
Mortuary and store	190
New bridge	481
Temporary isolation hospitals	458
New Street (Abbey Street) connecting High Street with Fairfield Road, including demolition and purchase of old property. (The Feoffees gave £1,000 in addition)	3,045
New intercepting sewer for parish of Little Bowden	850
Gas works and water supply for town purposes	1,097

URBAN DISTRICT RATES.

The Urban District Rates are 3*s.* 6*d.* in the £ per annum, and the money raised during the past year was expended as follows:—

—	Expenditure.	Receipts.	In the £ per Annum. Expenditure.	In the £ per Annum. Receipts.	In the £ per Annum. Net. +	In the £ per Annum. Net. –
	£	£	s. d.	s. d.	d.	s. d.
Loans (*see list following*)	4,101	..	2 2¾	..	..	2 2¾
Sewerage and sewage disposal	401	220	0 2¾	0 1½	..	0 1¼
Water supply	540	1,670	0 3½	0 11	7½	..
Main roads	710	576	0 4¾	0 3¾	..	0 1
Other roads and street works	1,040	50	0 6¾	0 0¼	..	0 6½
Scavenging ashes and streets and watering	487	..	0 3¼	..	..	0 3¼
Street lighting	804	100	0 5¼	0 0¾	..	0 4½
Isolation hospitals	407	100	0 2¾	0 0¾	..	0 2
Recreation ground	52	..	0 0¼	..	..	0 0¼
Public baths	234	139	0 1½	0 1	..	0 0½
Markets	454	1,095	0 3	0 7½	4½	..
Establishment and salaries	843	60	0 5½	0 0½	..	0 5
Horse account	290	..	0 2	..	..	0 2
Fire brigade	76	24	0 0½	0 0¼	..	0 0¼
Sundries	145	83	0 1	0 0½	..	0 0½
	10,584 4,117	4,117	5 9½ 2 3½	2 3½	11¾	4 5¾ 0 11¾
1*d.* produces £154, and 3*s.* 6*d.* produces £6,468.	6,467		3 6			3 6

Public Loans.

—	Amount Borrowed.	Now Owing.
	£	£
Sewerage and Sewage Disposal	25,825	8,338
Waterworks	24,920	12,112
Council Offices and Stables	2,458	1,966
Markets	25,950	24,543
Gas Works	49,000	45,087
Mortuary	100	100
Fire Station	550	521
New Street (Abbey Street)	3,050	2,898
Recreation Ground	3,200	3,200
Slaughter-Houses	700	697
Ashtip	425	403
	£136,178	£89,865

WATER SUPPLY.

The Author read a Paper before the Association on the Market Harborough Waterworks in 1891. For the convenience of Members attending the source of the water supply to-day, the following short summary of the paper dealing with this part of the subject is set out.

Mr. J. B. Everard, M. Inst. C.E., of Leicester, was the Engineer.

The level of the street in the centre of the town is 253 feet above O.D., but to command the highest house in the district a water-level of 415 feet was required in the service reservoir. To avoid a pumping scheme it became necessary to go very far afield to obtain a supply which would deliver naturally into this reservoir.

The Local Board having requested Mr. Everard to report upon the best means of supplying Market Harborough, Great and Little Bowden, with water, the now completed scheme was brought forward and approved, with the concurrence of Mr. James Mansergh, C.E. It is a gravitation scheme, absolutely unencumbered by any annual working expenses, such as pumping, softening, or filtering. The source, however, is 8½ miles away, lying partly in the parish of Husband's Bosworth, and partly in the parish of North Kilworth, in the county of Leicester, land having been purchased by the Local Board in both parishes, "with full and exclusive power, liberty, and authority to have, use, and take all water now flowing or what may hereafter flow through, upon, or over the said land." The vendors are also debarred from doing anything to the neighbouring land which might prevent the full flow of water through the subsoil to the places at which it now issues.

Previous to the acquisition of the land, permission was obtained for numerous trial holes to be sunk, and constant gaugings were taken for a considerable period, with very satisfactory results.

About one-half of the purchase area is grass land, bounded on the south-east by a stream; the other half is underwood, bounded on the west by the same stream which divides the two parishes. The land is half a mile in length, and averages from 33 to 100 yards in width.

The water is obtained for the most part from a bed of rock, this being one of the upper limestone beds of the lower lias.

In North Kilworth parish a well is sunk about 26 feet deep, and goes through drift gravel, in which only a small quantity of water is found, through lias clay to the bed of rock, which is nearly 1 foot thick. From near the bottom of this well a heading is driven, in which 12-inch stoneware socket pipes are laid, with junctions at suitable points provided with perforated stoppers, the average depth being about 24 feet for a length of rather more than 300 yards, with manholes at intervals. At the upper end extensive beds of gravel are found, and these are utilised as a natural reservoir, calculated to store 7,000,000 gallons, the water being kept back by a wall of puddled clay, but means have been adopted for automatically drawing off this water when it is required.

A second well sunk in Husband's Bosworth parish is about 24 feet deep, and is entirely in gravel, but a boring at the bottom of the well taps the rock below.

The water from both wells is conveyed by two 7-inch iron pipes to the valve house situate in Husband's Bosworth parish, and the supply is at this point automatically regulated by two self-acting float valves. There is also a small tank with screen, and in this tank begins the long 10-inch supply main which conducts the water to Market Harborough.

The water in the valve house is 450 feet above O.D., and the surface of the water on the upper side of the puddle wall is 473 feet.

The river Avon (which takes its rise from Naseby, at a height of about 560 feet above O.D.) receives the surface drainage of the locality.

The wells are 8 feet in diameter, and are built waterproof, except where provision has been made for the admission of water wherever it appeared in the excavation.

A daily supply of 170,000 gallons may be relied upon.

The water used for the public baths, street watering and market cleansing is pumped from a well at the gas works.

DISCUSSION.

The **President**: I have had the opportunity which many of you have not had up to the present, of going over the Market, and I will say what impression was conveyed to my mind. I have already said that I consider it reflects very great credit on Mr. Coales and his partner, and on the town of Market Harborough. I notice that there is no covered sale-ring. I do not know whether that omission has been noticed, and whether there is any want of that sort felt here, but I am told that a covered sale-ring is a very great advantage in a cattle market. It enables the seller and buyers in bad weather to be protected from the elements; and it enables the buyers to be seated and to see the cattle they are about to purchase without being hustled. Altogether, I am told that a covered sale-ring would be a very great advantage. I must say that I should have preferred to have seen more blue brick paving rather than some of the tar paving in places where the cattle congregate. I notice there is a rough surface to the tar paving which collects the manure, and although, no doubt, great attention is paid to the cleansing of the market, yet I should imagine there is a good deal of offensive matter left behind; and if, as stated in the paper, the drainage is turned into the sewers only on market days and cleaning days, then I think on other days, when there is a heavy storm of rain, the first flush admitted into the river would be polluted. Of course, it is for Mr. Coales to say what precautions he takes to prevent the pollution of the stream; but if precautions are not taken, the stream would undoubtedly be polluted. The cost of the fencing struck me as high when I read the paper, but when one came to look at the fencing one saw it must be expensive because it is very substantial, but no doubt it will be the more economical in the long run because of its substantial character. The paving of the cattle pens with dressed random granite setts gives the cattle a good foothold, but studded blue bricks would give an equally good foothold, and be easier to cleanse than granite setts with their wide joints ; while blue brick paving could be done for less than the other—probably half the cost.

Mr. T. W. A. HAYWARD: I would like to propose a hearty vote of thanks to Mr. Coales for so kindly inviting us here to-day, and for the two admirable papers he has placed before us. I remember the meeting here some eight or nine years ago, and although I was unable to be present, I do not think there is a meeting of the Association which has been held since that I have followed with greater interest. I thought Mr. Coales, in the earlier paper, went into details which we rarely get at these meetings. The same attention to detail characterises to-day's paper. A meeting of this kind is an inspiration to a man working in a small town. In many respects, it is more difficult to work in a small town than in a large one, therefore the surveyors working in such towns should have our sympathy and help. The statistics given in the paper show that Market Harborough is progressive in more directions than one. During the last twenty-five years, the town has increased in population nearly 100 per cent. Very satisfactory is this, but what is even more so, is that the death-rate has been reduced more than 50 per cent. This fact speaks volumes in itself. It shows that the health of the town has been well looked after. In the first place, Market Harborough has had a council alive to its responsibilities, has been advised by good officers, and the joint efforts have brought the town to the acme of perfection we see to-day. A death-rate which has been so largely reduced is most creditable. I do not think I have ever seen a more perfect illustration of what can be done by bringing a town up to a high state of sanitation. The list of public works is large for a town like Market Harborough, and, taking into consideration the work that has been done, one must come to the conclusion that the rates are low. I am particularly struck by the fact that the water supply and the markets bring in an amount equal to a shilling rate.

Mr. COALES: There are loan charges to come off that.

Mr. HAYWARD: It does not show that in the paper. It is carried out as net income—7½*d.* on the water supply and 4¼*d.* on the markets, a total of 11¾*d.* Apart from the loan charges it is a very good show indeed. I notice the money borrowed is just over 1½ times the rateable value. Here is a very good argument for some of the smaller towns, where directly one begins to borrow money to carry out public works the people say they are going to be ruined. The experience here again proves that money borrowed to carry out public works brings in a good return. Even if the return is not a marketable asset, the advantage is reaped in a lower death-rate, which should be considered as much as, or more than, a monetary return. The effect of putting these two things together shows that Market Harborough has been alive to its responsibilities and has made progress in every way. Mr. Coales is to be congratulated on the excellent way in which he has dealt with the question of cattle in a country market town. I have had experience of it in two towns where no cattle market existed, but where the sales were held in the public streets. In the town of Stamford, at the great fairs, as many as 10,000 head of cattle stood in the streets as well as 5000 or 6000 sheep, horses, pigs and other animals. In places where the streets are narrow, this is a source of great annoyance to the shopkeepers, to the public and to the Surveyor, because of the abominable nuisance they create, and the cost of cleansing and putting the streets again in order. Despite the nuisance and the cost the borough authorities cannot charge a penny for the accommodation. The farmers and dealers come in, use and abuse the streets, and the local authorities have no power to say move on, or to make them pay for the nuisance they create. Therefore, it is a fine thing that Market Harborough has been able to provide a proper market and so rid their streets of the cattle; I noticed that the roads in the market are made up with tar macadam, and I thought something more durable might, with advantage, have been used. In a cattle market it would have been advisable to put in, say, blue bricks. Some of my granite roads after having had sheep standing on them have been as bad as if they had not been touched for years.

Mr. W. Harpur: It gives me very great pleasure to second the vote of thanks to Mr. Coales for preparing these two papers, and for inviting us to this meeting. So far as I am personally concerned, it is a very great pleasure to come to a meeting in my native county. It is not often that I get an opportunity of paying a visit to this neighbourhood. It is my first visit to Market Harborough, and I have been particularly pleased with what I have seen to-day. Market Harborough seems an exceptionally well kept and clean town; the roads are the pink of cleanliness, and everything about the place makes it appear very inviting.

Mr. A. D. **Greatorex**: I should like to congratulate the council on the progressive policy it has pursued during the twenty-five years the town has been under its government. If you look at the statistics given in the paper, and at the works carried out, you will see that the town possesses its own water, gas-works and markets, and has carried out a successful sewage scheme. It can, therefore, congratulate itself on being up-to-date. As to the rates, it should be borne in mind that the 3*s.* 6*d.* rate si only the district rate. There are, in addition, the poor rate, the county rate, and the education rate. I should like to know what they are. The receipts from the supply of water, and the market total, as Mr. Hayward has said, to an amount equal to a rate of 11¾*d.*—practically 1*s.*; but there is still the interest on loans and the repayment of the money. The return on the water supply is equal to 4⅔ per cent. on the outlay, and on the markets 2½ per cent., so that when interest on capital is taken into consideration the markets cannot at present be paying their way. But when one takes into consideration that it is a new concern, one can hope that before long it will be able to pay its way and leave something over for repayment of loans. As I have had an opportunity of going over the market, I must say I was very pleased with the way in which the work has been carried out. My only objection is the same as the President's: I cannot quite agree with the random granite sett paving. I think blue bricks would have made a far more substantial and cleaner paving than the random setts. Still, I think the market is a credit to Mr. Coales, and also to the town. Although the iron fencing may appear rather expensive, yet some of the other work—particularly the roads—has come out fairly cheap. I find from the paper, that since our previous visit, the gasworks have become the property of the town. Referring to the paper Mr. Coales gave at the meeting in 1897, the price of gas was stated to be 3*s.* 1½*d.* per 1000 cubic feet, and the street lighting, single burners, 4*s.* 2*d.* per lamp per month extinguished at 11.30 p.m., and 8*s.* 10*d.* per lamp per month for those extinguished at sunrise. I should like to know what the price of gas is now that the gasworks belong to the town? Is it cheaper, or is it the same price? And I should also like to know about the street lighting. The prices given in 1897 were rather high. I should like a little further information as to the buildings of the market, the cost per cubic foot, and, if possible, the cost of each class of work separately. These figures are very useful for future reference. Although many of us to-day have nothing to do with markets, we never know what we may have to undertake. Municipal engineers have to execute almost all works under the sun. The latest thing I have had to write a specification for, is the repair of the town hall organ; I need not say that I am not an organist. I have, next week, to prepare a specification for the re-upholstering of the furniture in the council chamber. So one has a multitude of things to carry out. I look upon the volumes of our Proceedings as a most useful encyclopædia of knowledge. When you have to prepare a specification you turn to the volumes of the Association, or of the Institution of Civil Engineers, to look up the subject and to find the information to help you to carry it out. Therefore, I think the answer to these few questions, if added to the paper, would make it much more useful. Coming from the edge of the Black Country, though not actually from it, one likes to come into a town where you see the green fields and the general appearance of cleanliness. I would like to say a word about a new dust preventative—Akonia. At the present time we hear a good deal about dust preventatives, and most of us are trying one thing or another. Akonia is being tried on the stretch of road outside this building. I have seen one or two motor cars run over the road this morning, and it certainly has a surprising effect. I advise those who have not seen it to do so before they leave Market Harborough.

Mr. J. H. Jevons: I should like to ask Mr. Coales if the management of the market is in the hands of the Council, and if so, how these tolls are collected; why the tolls are higher for cattle sold by auction; and if the whole of the cattle entering the market pay toll whether sold or not, and who pays the extra toll for stock sold by auction?

Mr. N. H. Dawson: I should like to ask Mr. Coales whether there is any return on the gasworks? We have all the other accounts, but there are no receipts on the gas account. Surely there are some receipts which make up for the large expenditure in taking over the gasworks. I was struck with the wonderful reduction in the death-rate. I should like to ask whether there is any particular reason for that great reduction. Would Mr. Coales also state the price of the random setts per ton delivered in Market Harborough?

Mr. T. R. SMITH: I think the Author is to be congratulated upon being able to carry out a separate drainage for the market. The drainage of six acres of market may not be an important matter in a large town, but in the case of a thunderstorm or heavy rain it is a very great consideration in a small town. Mr. Coales says nothing about the cost and methods of cleansing the market. I take it the market is flushed from the hydrants and then well brushed. As to paving, I agree with Mr. Coales as to that which he has selected. We are not very fond of blue bricks in this part of the country; they are slippery and not cheerful in appearance. These random setts will not be very much trouble to keep clean, and I like this paving because with the large joints they do give a good foothold. Mr. Coales says the boundary walls of the market are coped with Weldon stone. Weldon stone is very absorbent, and I should like to know what was done to prevent the water getting down on the bricks below and bursting them with the frost. Then I see that slaughter-houses are being built; that they are not for public accommodation, but for private renting at 20*l.* per annum. Of course, a butcher may be glad to have a slaughter-house for private renting, but I should like to know whether there is any intention to let any of the slaughter-houses for common use. It is a matter we have had to consider at Kettering, but we have not gone further than that, for apparently there would be a good deal of opposition to the using of slaughter-houses in common.

Mr. A. H. WALKER: What means of disinfection are in use in the market to conform to the regulations of the Board of Agriculture?

Mr. A. J. DICKINSON: I noticed there were air-valves by the side of the road, so I assume the water main is carried in the same direction as the road. I also noticed certain points which appeared to be of high altitude, and I would like to know what depth these pipes are laid below the hydraulic gradient. It seems to me they must come within a few feet of it. The paper states that the market rights were purchased from Lord Barnard for 2455*l.*, and further on it says, that in addition, Lord Barnard presented the fair tolls to the town; I presume one refers to the weekly markets, and the other to the large annual cattle sale or fair. As a surveyor for five or six years to a market town, where cattle came and stood about the streets, I feel that it must be a very great boon to Market Harborough to have this market.

Mr. Coales: I must say how much obliged I am for the way in which you have received the paper, and for the friendly comments on it. First of all with reference to the use of tar macadam on the roads in the market. The tar macadam is very much less costly than the blue bricks, and in this locality we do not like blue bricks. We do not think they are at all in unison with a country rural district like this. If you will notice, these are roads and not pens, and the cattle are not supposed to stand on them. We have had no call for a covered sale-ring. I have no doubt it would be better for customers, but we have had no demand for it. The customers are not hustled in any way, because the pens are so arranged that they can see and feel every animal. Then, in the pens, granite setts are much better for giving a foothold to the animals than blue bricks. As to the cost of the fencing, we could not have had it done cheaper without scamping the work. We had tenders for it, and the lowest tender was accepted. The poor rate is from 1*s.* 10*d.* to 2*s.*, and that includes the education rate. The gasworks were purchased under a special Act, and that is why I have not put in the paper what they pay. The gas engineer, Mr. Harris, is here, and he will give you some particulars. As to the collection of the market tolls, we have a man at each gate, and every animal is counted into the market. Then the numbers are given to the market superintendent, who collects the tolls from the owners of the animals. Those animals sold by auction pay treble tolls, but if offered and not sold, they are only charged the ordinary rate. The market is cleansed in the way described by Mr. Smith. We have a hose from the ordinary stand pipes, and then when the pens are well washed they are swept. As to the use of Weldon stone for the coping, it is much cheaper than anything else, and we do not put it on the wall without having a damp course of slate and cement under it. The slaughter-houses are not let in common. The Board of Agriculture sent an official down to see me, and he said a good deal about limewashing and disinfecting, and what I had not done, but eventually we got a special order for the market (as it was properly constructed), and we got off any needless requirements of that kind. As to the sort of thing which was required, I may say that the posts had just been painted, and we were told to limewash them. The depth of the water-main is 4 feet all the way.

Mr. A. J. Dickinson: My point is that there is a hydraulic gradient from the pumping station to Market Harborough.

Mr. Coales: At the highest hill, we have about 12 feet to spare. The Lord of th eManor presented us with the pleasure fair tolls, that means the charge for roundabouts and things like that.

Mr. Harris: With regard to the first point mentioned by Mr. Greatorex, the maximum charge for gas is still 3*s.* 1½*d.* per thousand cubic feet, the same as when the Council took the works over; but we have made concessions to the large consumers which brings the price down to 1*s.* 11*d.* per thousand cubic feet for them. Before long the Council will however be in a position to give further concessions, which will bring the price down lower all round. With regard to street lamps, the charges are practically the same, but we have No. 4 Kern incandescent burners fitted in most of the lamps, and in some cases we have two or three lights burning in a lamp, and we do not charge more for lamps of higher candle-power. Our receipts now amount to about 9300*l.* per annum, and the expenditure on revenue accounts amount to about 6300*l.* We have never yet had to touch the rates for any money in connection with the undertaking, and in six years we have built up a reserve of 1500*l.* beside paying off 900*l.*, the parliamentary costs incurred in the transfer of the undertaking; and, in addition to meeting the usual charges for interest on loans, have repaid principal on such loans to the extent of 3912*l.*

The works have more than paid their way and have given the rates a little assistance.

The President: I should like to say that I hold no brief for blue brick manufacturers, but have suggested the use of blue bricks from a purely sanitary point of view. Mr. Coales misunderstood me, when he referred to the roads as being roads and not pens. I do not wish him to put down blue bricks for the main roads of the market. If you notice on going round the market, you will find that the tar paving is much caked with manure. It was from that point of view I urged the use of blue bricks, and not the other.

The vote of thanks was carried unanimously.

RIVERS CONSERVANCY.

By HERBERT G. COALES, Assoc. M. Inst. C.E., F.S.I.

River Welland at Market Harborough.

Market Harborough is situated on the river Welland, four miles from its source at Sibbertoft. This river flows into The Wash, a distance of about 45 miles, as the crow flies, from Market Harborough. It is not an important river here, as Members may have noticed in crossing it from the railway station; but although so small it is quickly affected by heavy rains—rises rapidly and overflows its banks.

No doubt in prehistoric times floods broadened themselves out in the Welland valley, fulfilling their purposes for good in the economy of nature; but with the advent of man, with his dwellings on the banks of the river, floods became a source of suffering. A great flood occurred in Market Harborough in July, 1880, when the water stood many feet deep in the square. The causes of the flood were: neglect of the river and its tributary watercourses, with serious encroachments into its channel, owing to absence of effective supervision and control by any statutory authority.

There have been other floods since 1880, but none of such a severe character, by reason of some improvements to the river carried out, and obstructions removed, by private enterprise. But had it not been for this enterprise, floods would have been a perpetual menace to the prosperity of the town. Improvements are now required to make the town absolutely secure from floods; but where is the power to move? The Urban District Council cannot move; the County Councils (for at Market Harborough the Welland divides two counties) cannot move; and it occurs to the Author that the time is more than ripe for the Legislature to move in the direction of the establishment of River Boards, having control of each river from its source to its outfall, as contemplated by the abandoned Bills of a quarter of a century ago. Ought such a condition of things to be tolerated as described in a daily paper, not so long ago, of a certain town?—"Over two feet of water is in the lower rooms of the houses, and many families, who have not left, have taken refuge in bedrooms. Cocks and hens are seen roosting and starving in the trees, but in some cases they and the pigs share the cottages with the inmates. Punts are in use in the public streets."

As representing a body of men interested in the health and comfort of the inhabitants of this country, it may not be considered out of place for the Association to support any voices raised in favour of the establishment of River Boards or analogous bodies. The Author proposes in this paper to suggest reasons for the establishment of River Boards, with some notes on the matters which would come under the observation and control of such bodies.

Even a small river in flood seems, and is, a formidable fact to the people living upon its banks; but it is obviously a weak thing to say that it is impossible to remedy such a condition. When the river Welland below Market Harborough overflows its banks, spreading its flood-water over the valley until it gets a quarter of a mile wide, people imagine it cannot be helped; but if a channel of the capacity of the River Thames, for instance, were substituted, it is evident there would be no more floods in the Welland Valley. The whole question is one of degree. In districts where floods do harm, the rivers should be improved and the evils remedied; in localities where floods do no harm to immediate owners, or to others at a distance, no one, of course, would dream of interfering or expending money on useless work.

EXISTING LEGISLATION.

That floods have not always been classed with earthquakes and tidal waves, as acts of God, is evident from the fact that legislative attempts have been made in the past to deal with them.

With regard to existing legislation, the first public statute which undertook to deal with river conservancy, and that upon which all subsequent legislation in reference to the subject was founded, is the 23 Henry VIII. The statute provided for the appointment of Commissioners of Sewers (who remained in office during the royal pleasure), with very extensive powers for taking such measures as they might think proper for preventing floods and improving the state of rivers. The expenses which they might incur for works of repair, demolition, or improvement, were to be defrayed by the riparian owners in proportion to the benefit derived from the works. Subsequent Acts defined and extended their powers; and in the year 1861 further provision was made for the drainage of agricultural lands by the Land Drainage Act (24 & 25 Vict. c. 133) in which the representative principle was adopted, as regards the selection of persons to deal with arterial drainage. This Act did not materially affect the constitution or functions of Commissioners of Sewers.

SELECT COMMITTEE OF HOUSE OF LORDS 1877.

The Select Committee appointed by the House of Lords in 1877, to inquire into the operation of existing statutes in regard to the formation of and proceedings by Commissioners of Sewers, and Conservancy, Drainage and River Navigation Boards, reported that it was generally acknowledged that the Acts had not worked successfully for the prevention of floods, owing partly to the defects in the machinery provided for carrying the Acts into execution, and partly to obstructions caused by private legislation relating to drainage, navigation, and matters of a similar kind. It was stated that there were between 2000 and 3000 of these private Acts. The Committee recommended that, in order to secure uniformity and completeness of action in dealing with each river, each catchment area should, as a general rule, be placed under a single body of Conservators, who should be responsible for maintaining the river from its source to its outfall in an efficient state: as the existence of several distinct authorities for the course of a single river was fatal to the adoption of any uniform and comprehensive scheme for the conservancy of the river as a whole. The jurisdiction of the Conservancy Board should include the power of removing obstructions, improving outfalls, and of deepening and dredging the bed of rivers, and such power of dealing with river banks and bridges, and of compulsorily acquiring land at a fair compensatory value, as might be conferred upon them by Provisional Order. Duly limited powers of rating should be conferred upon them; also the administration of the Rivers Pollution Prevention Acts. The Committee further recommended that the rates required to meet the expenses of conservancy should be distributed over the whole area of a watershed, the lands and houses below the flood-level being rated at a higher amount than those above it, and other graduations and exceptions being made to meet particular cases.

CONSERVANCY BILLS OF 1881 AND 1882.

Following upon the report of the Select Committee, Bills were introduced into Parliament in 1881 and 1882 dealing with the Conservancy of Rivers and Prevention of Floods, but neither of them passed into law.

The duties of the proposed Conservancy Boards were to include the cleansing, repair, and maintenance of all existing watercourses or outfalls for water, and all walls, embankments, or other defences against water: the deepening, embanking, or otherwise improving any watercourse, and altering or improving, any mill-dam or similar obstruction, and the construction of any new watercourse, dam, or embankment. The Bills provided for the division of the whole kingdom into three classes of lands, viz.: lowlands, midlands, and uplands. "Lowlands" were lands liable to ordinary floods; "midlands," liable to occasional floods and obstruction by flood of drains; and "uplands," all the remaining lands.

ROYAL COMMISSION OF 1898.

The Royal Commission on Sewage Disposal, appointed in 1898, has reported in favour of the setting up of River Boards, with the watershed as the administrative area, having control of the streams in respect to pollution, water-supplies, and fisheries.

If, therefore, Parliament would pass a Bill based on the conclusions arrived at, after hearing expert evidence, by its Select Committee and its Royal Commissions, the country would greatly benefit.

REASONS FOR INACTION.

If the whole condition of the watercourses of England is looked at broadly, it is difficult to believe how people have tolerated their neglect so long. We have not so treated the question in Egypt! No doubt, if there occurred several consecutive years of excessive rainfall, or, on the other hand, of drought, the question would be forced into practical politics again; but the law of averages works in favour of letting things alone.

It appears there are two reasons why authorities have not hitherto been established for the management and control of our rivers and streams:—

1. The unwillingness of legislators to interfere with private property, vested interests, or prescriptive rights.

2. The difficulty of propounding an equitable rating scheme to provide the necessary funds for the administration by the River Authority.

With regard to the first objection, the riparian owners, having failed to remedy the existing evils with their present powers, and a case having been made out for action, Parliament should intervene in the interests of the community at large.

Respecting the second objection, it should not be beyond the wisdom of Parliament to devise an equitable rating basis for one more body, having regard to the number of administrative bodies already established.

In the event of River Boards being established, there can be little doubt the Members of our Association will be interested directly or indirectly in their administration. With this supposition in view, the Author proposes to set out in a few notes what he conceives are matters which will have to be considered by the Boards.

RAINFALL.

The average rainfall for the 45 years ending in 1902 (as given in "British Rainfall") was approximately 25 inches, whereas the exceptional floods of 1903 were caused by a rainfall of 36 inches. If rain fell at a fairly uniform rate throughout the year, the rivers and streams would pass the flow off to the sea in a steady manner without difficulty. But the rain does not. At one period we have a deluge, and a flood; at another an entire absence, of rain, and a drought. Both are bad, and a corrective of a different nature is required in each case: in the one case an improved channel, in the other a storage of water for purposes of irrigation or domestic use. We must never forget Providence has bestowed upon the British Isles a supply of rainfall ample for all purposes—beneficial when controlled, disastrous when neglected.

DATA.

One of the duties of a River Board would be to gather reliable data as to the rainfall in the watershed under control, together with the known flood-heights, the strata of the districts, etc., upon which the remedial works could be based. Observations and records of various important matters would, in the course of a very few years, lead to a thorough knowledge of the eccentricities of the streams. It should not be impossible in most districts to know at different degrees of saturation of the subsoil just how much rain, falling in a given time under present conditions, would cause a flood, how long the flood would be in rising, and its duration.

FLOODS.

The Select Committee of the House of Lords reported that, in the opinion of several witnesses of experience, floods of moderate duration are not always prejudicial, but, on the contrary, have the effect of improving and fertilising grass lands by the deposit which they bring down; and that in such cases it is mainly when, owing to insufficient arterial drainage or other causes, flood waters are suffered to stagnate upon the soil for a lengthened period, that injurious consequences are found to arise. In fact, it has been urged as a reason for not taxing the uplands for river works, that they contribute to the value of the lowlands, by sending down fertilising and enriching products in the way of manure and soil during heavy rains. On the other hand, the lowlands, whilst accepting the involuntary gift, think it does not compensate them for the damage caused by the more rapid discharge of upland flood-water, caused by the improved systems of land drainage, and the better cleansing of ditches. Again, no one can make out a case for floods being a benefit to towns; on the contrary, they are disastrous and pestilential in the extreme. Floods are detrimental to arable land, and in a valley liable to floods only a pasture should exist.

STRAIGHTENING, WIDENING, AND EMBANKING RIVERS.

If one could take a certain river and measure the distance as the crow flies from its source to the sea and divide by the total fall we should not get its true hydraulic gradient, as its meandering and twisting and doubling would make the real distance much greater. We know that the sharper the gradient the less sectional area of waterway is required to pass off a given amount of water; it is evident, therefore, that the straighter the channel, the sectional area being the same, the quicker will the water get to the sea. The channels should therefore, where practicable, be straightened, and the loops cut through, as this may save widening. Where the channels cannot be straightened they may be widened, and where they cannot be straightened or widened they may be embanked or deepened. Embankments appear to be the cheapest way of keeping floods under control in most of our English rivers. An objection to embanking has been raised in districts where there are no waterproof soils within reach, but a flood usually is of such short duration that the water would not have time to percolate through the porous subsoil before the flood subsided again. Where an embankment is made by the side of a river, it might be necessary to construct an intercepting drain parallel with it on the land side of the embankment away from the river, for the drainage of the land with an outfall at a lower reach of the river, otherwise some land would get waterlogged. Embankments would have to be thrown up at such a distance from the ordinary channel as to make such a sectional area as would be capable of passing on the largest known amount of local flood-water. Each river or part of a river would have to be separately studied, and the embankments varied accordingly. It is obvious that the land between the embankments and the river would not do for anything but grass land. Cereal crops and roots would be carried away, and osiers would cause obstruction during a flood.

It would tend to the improvement of land—or, at all events, in the direction of preventing its deterioration—for a Board to give landowners a good and sufficient outfall for their land drainage; now often an impossibility owing to the absence of co-operation between neighbouring owners.

OBSTRUCTIVE BRIDGES AND WEIRS.

There are bridges which would be sufficient for passing on flood-water were the side-arches kept clear of sediment and obstructions; but, on the other hand, there are other bridges which are great obstructions themselves with insufficient waterway, either in width, or head-room, or both. Mr. M. O. Tarbottom, of Nottingham, stated before the Lords Committee that the old Trent Bridge, built 800 years ago, obstructed the water 16 to 18 inches. The County Councils of Leicestershire and Northamptonshire, with the local authorities, have recently substituted an iron lattice girder bridge in place of an obstructive brick bridge over the river Welland at Market Harborough. This old bridge held up the flood-water some 18 inches. It is to be hoped, however, that no picturesque old bridges would be pulled down unless absolutely necessary, as it would be possible in many cases to relieve the pressure by means of additional flood-arches and wallows without perpetrating acts of vandalism.

The Lords Committee reported, with reference to mill-owners: "The removal of obstructions would frequently necessitate an interference with prescriptive rights of mill-owners and others in respect of dams, and weirs, and mill-gates; and the Committee think that, whilst such rights should be made the subject of compensation when requiring to be interfered with, great caution should be exercised in dealing with them, as the evidence before the Committee points to the conclusion that weirs and dams, when constructed in a proper manner, are not necessarily prejudicial. The Committee are of opinion that it should be competent to the Conservancy Board to take such steps, by arrangement or otherwise if necessary, as shall provide for the opening of mill-gates in the event of a flood or expected flood."

Major Flower (Engineer of the Lea Conservancy Board) said—"I can verify the statement that water-mills occasion floods, and also droughts of water. I strongly advocate the doing away with mills, or having them under control." Opinions, seemingly opposed, may possibly be reconciled by remembering that each river has its own characteristics and peculiarities, and is open to different modes of treatment.

DROUGHT. IRRIGATION.

The occurrence of calamitous floods must never make us forget that there are such evils as droughts, when vegetation is burnt up for lack of moisture, and farmers and graziers would give almost anything for water. Here, then, is scope for the attention and foresight of a River Board. To the extent to which it is possible, means should be devised for holding up the level of the available water in the rivers and tributaries for the irrigation of land lying below that level. This could be accomplished by the installation of movable gates, placed either in the main stream or in a sufficient tributary stream, and the water conveyed from the upper side of the weir by a side channel, or by a system of pipes, to the land below. To an extent this is now done in some counties, but not to the extent it might be under the direction of a controlling Board with extensive powers. In some localities it would be quite feasible to impound flood-waters in storage reservoirs at sufficient elevation to command certain midlands and lowlands.

WATER SUPPLY.

It is generally conceded that the storage of flood-water has an infinitesimal effect in the mitigation of floods: the quantity of water which it is possible to hold up being so very small in comparison with the water rolling down the stream. But whilst this fact is true, it is most desirable to store water for purposes of water supply, municipal purposes, and irrigation.

In many districts the acquisition of land for the construction of impounding reservoirs would not be a very serious affair, with the low prices of land obtaining to-day.

There seems no reason why each River Board should not allot—on paper at all events—sources of water supply for every town and village within its watershed. This would prevent the larger towns, with the longest purses, inequitably securing what ought really to be the supply of some smaller place. On the other hand, it would lead to the economising of the available supplies, by preventing districts from monopolising far more gathering ground than was reasonable for future use. In England it must always be remembered that the watersheds are constant, whilst the population is increasing; so that the conservation of water is really a question of national importance.

Prudent considerations should prompt authorities to conserve flood-waters during wet seasons to augment existing supplies during times of drought.

It has been suggested that shafts or dumb wells might be sunk in some localities in water-bearing strata and flood-water turned into them, so that the underground reservoirs might be replenished. This is a matter that should receive the closest attention of any authority having jurisdiction in a watershed. Mr. J. Bailey Denton, C.E., told the Lords Committee in 1877 that the under-drainage water in England and Wales might in wet years equal a new Thames in volume.

Having seen that the tendency of modern drainage is to hurry the water from the land to the rivers as quickly as possible, it is obvious that permeable strata has less opportunity of arresting the water than before the drainage era, when natural percolation was greater. If, then, we cannot have sufficient underground storage of water for our town supplies, we must impound the necessary amount of flood-water in open reservoirs.

The Board of Agriculture have recently recommended to water authorities the afforestation of catchment areas. This would tend to keep the water supply purer, and increase infiltration by arresting evaporation.

WATER POWER.

Whilst the owners of existing water-mills would of course be privileged to retain their water rights—always provided those rights were not detrimental to the public weal, in which case their suppression would be subject to compensation—the River Board would in certain cases be able to lease water power to landowners and others where the levels and conditions were possible. A survey and consideration of the whole watershed would reveal, in many localities, possibilities for the utilisation of water-power at present overlooked, or impossible to utilise under the present limited jurisdiction.

PLEASURE.

It does not require any great stretch of imagination to conceive of the very great source of pleasure which a neglected, shallow, offensive river through a town would become if transformed into a cared-for, embanked, and clean stretch of water, with its facilities for boating, bathing, and skating. Those towns which have already acquired power of control, and carried out schemes of river improvements, certainly have added very much to their beauty and attractions. Equitable arrangements no doubt would be made between River Boards and the local authorities for facilities in the execution of such local improvements. Common honesty would preclude money being expended on what might be deemed a luxury from the treasury on the River Boards, for the benefit alone of a particular community: one would imagine a River Board to be a strictly business authority, jealous of unnecessary outlay, working for the watershed as a whole.

NAVIGATION.

It is not now practicable to copy navigation in its most primitive form, when transport was carried on by the aid of stanches. Neither is navigation, as we know it, practicable at all on some rivers; nor remunerative on others, having regard to the facilities of transport given by railways. On the other hand, navigation is quietly being prosecuted on some navigable rivers, and possibly might be extended to others. There are certain classes of merchandise which do not call for great speed in delivery, and in those cases navigation would be useful. The little competition, too, arising with some of the railways would not be a disadvantage to traders. Navigable rivers should be considered as analogous to roads, and as much care should be bestowed upon them. Cheaper inland transit for our industrial products would be of great benefit to the country in meeting foreign competition. The canal pioneer did good work in connecting one river with another by means of canals: the railway companies, however, have obtained 1200 miles or so of canal, and "so adroitly selected as to strangle the whole of the inland water traffic," said a witness before the Select Committee of 1883.

Rivers being natural streams falling towards the sea, present the initial difficulty to navigation, inasmuch as they entail the provision of locks in all up-country reaches. These locks might be considered accessory to the making of floods, although the before-mentioned expert evidence given before the Select Committee does not bear out this misgiving, where the locks and weirs are properly arranged and placed.

LABOUR.

The control of a watershed by a River Board would lead to the employment of a considerable amount of labour in the country. Not that labour would be employed for the sole purpose of giving relief to the unemployed, for that might be unremunerative, whereas the object of the Board would be to execute work calculated to benefit property, and the comfort, health and prosperity of the community.

On the other hand, it is obvious how much labour might advantageously be employed in the execution of what are now neglected duties. How choked and overgrown with weeds and obstructed by living and fallen trees are many streams! How seldom are accumulations and silt banks cleared away or the banks cared for! Culverts and drains are allowed in some cases to practically silt up, and ditches and watercourses overflow for want of attention. How many side arches of river bridges have lost several feet of head-room by the neglect of flood deposits!

New works, too, would largely entail the employment of labour, such as the construction of embankments and flood-channels, training of rivers, piling works, building weirs and cutting drains.

FISHERIES.

The Royal Commission on Sewage Disposal and the Salmon Fisheries Commission agree in recommending the setting up of a Board capable of dealing with the fisheries of an entire watershed and with all tidal waters, with power to control foreshores and to prevent the taking of shell-fish for human consumption from any position liable to risk of dangerous contamination. When sewage and chemicals are kept out of the fresh waters of the British Isles, it does not seem too much to hope for a reversion to the well-stocked fish streams and ponds of our forefathers. In some localities it requires a stretch of imagination to believe that our modern word "weir" is derived from an Anglo-Saxon verb meaning a barrier in a stream to hold up or enclose water for catching fish.

RIVERS POLLUTION.

The Royal Commission on Sewage Disposal recommends that the Rivers Pollution Prevention Acts should be administered by the Rivers Boards.

DISCUSSION.

The **PRESIDENT**: I must congratulate Mr. Coales on writing this paper and bringing the subject before the Association. Until we have River Boards throughout the country, I am afraid our rivers, instead of being brought back to their original clear and pellucid state, will continue to be streams very much polluted. I think that if the country generally were to follow on the lines of the Yorkshire Rivers Board, it would be for the good of the country. I noticed in passing over the bridge near to this room that the river, which divides the counties of Leicester and Northampton, appeared to be somewhat polluted. If you had a River Board here, it would most likely cause some change to be made even in this locality.

The **CHAIRMAN** (Mr. Douglass): It is not caused by us, but by a village higher up the stream.

The **PRESIDENT**: I think the time is not far distant, when we shall have rivers boards formed. There is a commission now sitting on the subject of sewage disposal. It seems that the formation of Rivers Boards is within measurable distance, and the sooner they come about the better it will be. We have improved our roadways, and it is about time we began to improve our rivers.

Mr. E. J. Silcock: I have great pleasure in proposing a vote of thanks to Mr. Coales for his paper on this subject. Rivers conservancy, as the President has said, is a subject of the greatest importance, and as I come from the West Riding of Yorkshire, where the Rivers Board is somewhat active, I can tell you that they have done a considerable amount of good in keeping pollution out of the rivers in their district. But they have not sufficient powers, and they are in the unfortunate position of not being able to get further powers. They proposed to go to Parliament this present session, but an action was commenced against them by one of the contributory bodies to prevent them applying their funds for the purpose of promoting a Bill in Parliament. They are in this position: they have funds to spend, but cannot spend them on getting further powers. That cripples them to some extent, and there will have to be some public legislation introduced to invest them with considerably more power than they have at present. The sewage commission appears to be one of those things which go on for ever. They have issued several interim reports, but do not appear to be getting nearer to a conclusion of the whole matter. One of the great difficulties, which was referred to by the Author in the paper, is the difficulty of propounding an equitable scheme of rating, and that is one which strikes at the root of the whole matter in all sorts of districts, not only in town districts, but in country districts as well. In the town districts if you are going to keep pollution out of the rivers, you are going to destroy to a very great extent some of the manufactories. On the other hand, if in country districts you are going to carry out large works to prevent floods, you are going to spend such large sums of money as to cripple the land. I have had some experience in that direction. At one time I was engineer to the Nar Valley Drainage Board. That board was formed to improve the river Nar, and to so drain the land as to prevent flooding. The principle of rating adopted was to divide the district into three zones, which were rated on a differential basis. All the works were carried out and, when completed, the lowest portion—the flood zone—was rated to such an extent that the land would not produce the rate, and the board had to sequestrate the land. That board—the chairman of which is a member of Parliament—is to-day in possession of land in the valley which has been given up by the owners, who said, "You can take the land and get what you can from it, but we cannot afford to pay for that land the rates asked from it." As a matter of fact the land was not benefited to the extent anticipated by the drainage. The peat land which was drained did not produce as good herbage as before, and some of the land in the higher parts of the valley was over-drained, and the water supply for the stock was insufficient in dry weather. In that particular case the improvement works were not by any means a great success.

Mr. A. J. DICKINSON: I would like to say a word as to the effect of flood-water on grazing land. I was formerly in a rural district. It was on the river Thame, a tributary of the Thames, and it had a conservancy board. They were very careful as to preventing any pollution of the river, but when it came to doing anything themselves it was another matter. It was very liable to floods, and in 1903 the land was flooded the greater part of the summer. Whenever there are floods, a deposit is left on the land, so that the farmers dare not place cattle on the land for some time, and the grass for grazing purposes is practically valueless.

Mr. J. S. PICKERING: The town of Nuneaton which I represented a few years ago was subject to floods, and an important scheme for their prevention is now being carried out by Mr. Cook, my successor. Mr. Coales suggests that neither the Urban Council nor the County Council can move in the matter of floods. I do not agree with him. Market Harborough appears to be placed in much the same position as Nuneaton. The Nuneaton authorities promoted a Bill in Parliament, carried it through, and now the scheme is being carried out at a cost of 10,000*l.* One great hardship in approaching Parliament is the enormous expense involved in getting Bills through. This particular Bill, although there was practically no opposition, has cost the town something like 1200*l.*, and I need hardly say that this has not gone into the pocket of the engineer, who has done the bulk of the work. There is not much help to be got from the Local Government Board, because they made a stipulation that the money shall be paid off in five years. It is costing about a penny rate to pay off the promotion expenses, while the cost of the actual work is spread over thirty years. Mr. Coales expects the riparian owners to bear a share of the cost of doing this work. I do not think it is the duty of riparian owners to undertake river improvements. I think the work should be undertaken by the people who are going to benefit by it. I agree with Mr. Coales as to the desirability of placing the rivers under the control of river boards, and I think the recommendations made by the Select Committee of the House of Lords, and later by the Rivers Pollution Commission are what should be ultimately carried out. There is no doubt that river boards are a necessity, if we are to properly deal with the flooding of towns and the pollution of rivers in a satisfactory manner.

Mr. T. R. SMITH: There is some work in connection with rivers conservancy, in which the riparian owners might take a share. Take the question of water supply. When we construct a reservoir for the supply of a town, that work is largely made into a work of river conservancy. You go to a very large expense and then you find that one-third of the water has to be given back to the brook as compensation water. It is not right that we should take the whole of the water, but one-third is very much more than compensation. It occurs to me that something smaller than one-third should be the amount to be given to a brook, and if the riparian owners want more, they should pay something for that from which they benefit so much. It is pointed out in the paper that many of the streams are very much neglected, and their course very much choked and overgrown with weeds. Quite apart from sewage pollution a large amount of natural pollution takes place, and exercises the maximum effect on rivers choked with weeds. The nearest town is always blamed for this pollution, whereas if the streams were kept clear of weeds, the water would get away more quickly and have no effect on the stream.

Mr. F. C. COOK: I have read Mr. Coales's paper with very great interest, and I think he is to be complimented on having brought a very pressing matter before the Association in such a lucid manner. The cost of obtaining the requisite powers prevents a great deal of necessary work being carried out by the smaller towns all over the country. It nearly led to the council at Nuneaton dropping the question of floods prevention altogether or tinkering with it from money available from the current rate. We first had to make application to the Local Government Board, an inquiry was held, and then they referred us to the Board of Agriculture and Fisheries. What the Board of Fisheries had to do with a river which had not had fish in it for years I cannot tell. If it had not been for the fact that eighteen months since we nearly had a repetition of a flood of four years ago, when the damage to one large factory was assessed at 9000*l.*, and the cost to the town was double that amount, I believe nothing would have been done, but the matter was regarded as so serious that we were absolutely driven to obtaining Parliamentary powers. I think it is something approaching a scandal that a small community should have to pay such an amount of money to obtain powers to do necessary but quite unremunerative work. The cost of obtaining our Bill, which has to be paid for in the next five years, will be more during that period than the annual payment of principal and interest in respect of the cost of carrying out the work itself. Whether the object aimed at is to be attained by the constitution of Rivers Boards is a difficult matter to determine, particularly after what Mr. Silcock has said. I do not think the multiplying of these rating authorities is to be commended, but I certainly think it is a matter in which legislation should be resorted to.

Mr. Coales, in reply, said: This is not my question but everybody's question. Mr. Pickering criticises one note in the paper that I do not think the urban district council can move in this matter. I do not think we can. If a district happens to extend a quarter of a mile beyond the town, your Bill would not cover the district beyond your own boundary. If you cannot carry the work to the outfall, and get that properly constructed, it is useless to do work in your own district. You want the whole course of the waterway improved.

The President: I think when the Rivers Boards are formed the sooner the absurd local boundaries are altered so as to coincide with the boundaries of the watershed areas the better.

The President moved a hearty vote of thanks to the Chairman and Members of the Urban District Council, for the use of the Council Chamber for the Meeting, which was seconded and heartily accorded.

Mr. Coales entertained the Members attending the Meeting to luncheon in the settling room at the Market. The afternoon was occupied with the inspection of the Market and Buildings, Fire Station, and Waterworks. On returning to Market Harborough, the Members were hospitably entertained to tea by Mr. Clark at his residence.

WESTERN DISTRICT MEETING AT GLOUCESTER.

June 3, 1905.

Held in the Council Chamber, Guildhall, Gloucester.

A. T. DAVIS, M. INST. C. E., PRESIDENT, *in the Chair.*

THE Mayor (Councillor W. Langley Smith) received the Members and offered them a hearty welcome to the town.

The President, on behalf of the Association, thanked the mayor for the very cordial reception he had given them, and took the opportunity of offering the congratulations of the Association to the city surveyor on his election to a seat on the Council of the Association.

The Minutes of the last Western District Meeting were read, confirmed, and signed.

Mr. J. S. Pickering was unanimously re-elected Honorary District Secretary.

The following papers were read and discussed.

MUNICIPAL WORKS OF THE CITY OF GLOUCESTER.

BY R. READ, A.M.INST.C.E., CITY SURVEYOR.

HISTORY.

THE city of Gloucester is one of the most ancient in the kingdom. The ancient Britons called it Caer-Glowe or the "Fair City." The Romans, who enclosed it with a wall seven feet thick, and established a garrison here about A.D. 43, called it "Glevum," and kept up constant communications with other

Roman stations at Cirencester, Colchester and other places by means of the "Ermine Street which was constructed in the reign of Nero." They also for over four hundred years kept the Silures (Welsh) at bay on the western side of the Severn. The Saxons called the city "Glow-ceaster," and it became one of the chief cities of the Saxon kingdom of Mercia. In 896 King Alfred held a Witenagemote, and Athelstan died here in 940. In 964 King Edgar resided here. Canute the Dane and Edmund the Englishman met here to divide the realm. William the Conqueror held his Council here, at which the Doomsday Book was planned. He also spent Christmas here, as did William Rufus, and Henry I. acquired his fatal fondness for lampreys, to commemorate which the Mayors of Gloucester have since been honoured by the acceptance by the reigning monarch of a lamprey pie annually.

Henry II. granted the city its first charter.

Henry III. was crowned at Gloucester Cathedral.

Edward I., Richard II., Henry IV. and V. held Parliaments here; Richard II. granted a charter; Henry VII. passed through en route for Bosworth field; Henry VIII. and James I. visited the city.

Bishop Hooper of Gloucester was burnt at the stake by order of Queen Mary. Archbishop Laud was Dean of Gloucester; and on August 10, 1643, King Charles I., with his two sons and Prince Rupert, besieged the city with 8000 men for a month, until it was relieved by Lord Essex.

At the restoration of Charles II. he ordered the destruction of the fortifications, which had been re-built on the old Roman foundations by the Normans after the damage done during the wars of the Saxon period, and he granted a new charter for a consideration; thus he "drew the teeth" of his father's enemies. In the seventeenth century Gloucester became a port, and gained wealth and prosperity by pin making, bell founding, and glass making.

The chief ornament of the city is its fine cathedral, containing beautiful stained glass windows, and magnificent examples of architecture varying in style from early Norman down to perpendicular. The Saxon king Osric, Robert Curthose Duke of Normandy (eldest son of William the Conqueror) and King Edward II. lie buried within its walls. The crypt, the chapter-house (in which the Conqueror held his Parliament), the nave, chancel, lady chapel, and cloisters, are all splendid specimens of their respective styles of architecture.

The city of Gloucester is situated on the east bank of the eastern channel of the river Severn, 110 miles from London on the Great Western Railway; 56 miles south of Birmingham, and 36 miles north of Bristol by the Midland Railway, both companies having stations at Gloucester.

The river Severn runs from north to south, and divides into two channels, east and west, at the "Upper Parting," 2 miles 650 yards above Gloucester, and re-unites at the "Lower Parting," 1 mile 273 yards below, forming Alney Island between the two channels.

Gloucester is the most inland port in England, with docks capable of accommodating vessels up to 1200 tons register. These docks are connected to those at Sharpness lower down on the estuary of the Severn by a ship canal, opened in 1827, 16 miles in length without a lock, the distance by the river being 30 miles. The docks at Sharpness can accommodate vessels up to 6000 tons register, and a large trade is done both here and at Gloucester in corn and timber, salt, and general cargoes, there being regular traffic to and from Hamburg, Antwerp, the Baltic, Mediterranean, Black Sea, and South American and North American ports.

The valley of the Severn at Gloucester is about 12 miles wide, bounded by the Cotswold Hills on the east and the Monmouthshire and Herefordshire Hills on the west.

The valley near the river is on the lower lias clay, which at Gloucester is covered with large deposits of oolite and northern drift gravel. The lower lias clay thins out to the north and west of the city, and the new red marls come to the surface at from 3 to 6 miles in those directions.

Across the valley to the east in the direction of the Cotswold Hills, the lower lias is overlapped in succession by the marl stone, the upper lias clay, and the oolite formation, which forms the capping of the Cotswold Hills. The new red sandstone comes again to the surface to the south of Gloucester, near Mangotfield, on the Midland Railway.

On the western side of the valley are the coal measures of the Forest of Dean, and the old red sandstone of Herefordshire.

The city of Gloucester has three natural water-courses flowing through it, rising from the slopes of the Cotswold Hills, viz., the Twyver, flowing from the north-east towards the Severn on the west, near the northern boundary of the city; the Sudbrook, flowing from east to west, just below the centre of the city; and the Tweenbrook, flowing from south-east to west, near the southern boundary of the city.

The Cross, which is the business centre of the city, is on a slight elevation 66 feet above O.D., between the Twyver on the north, the Sudbrook on the south, and the Severn on the west.

WATER SUPPLY.

There can be no doubt that the ancient city owes its existence to the excellent facilities which the river Severn and the watercourses flowing into it afforded for water supply and navigation, while shallow wells sunk in the gravel deposits over the lower lias clay provided an abundant supply of water. As time went on, and these sources became more or less polluted, water was first brought from the outside, from Robinswood Hill, an outlier of the Cotswolds about two miles south-east of the city, in lead pipes, and in the seventeenth century pumps were erected on the banks of the Severn near Westgate Bridge, worked by a water wheel, forcing the river water through wooden pipes formed of young elm trees bored out and cut at the ends to spigot and socket joints, the sockets being strengthened with iron bands. The water was pumped to the top of the tower of a church in Westgate Street (demolished in the eighteenth century), and the Robinswood Hill water was supplied to a point (Scrivens' Conduit) in Southgate Street, near the present Corn Exchange, where there was an ancient market house in the centre of the street.

In 1855 the Robinswood Hill supply was in the hands of a company, who had constructed reservoirs there and laid on the water to some of the principal houses by means of cast iron mains and lead service pipes, and the demand becoming greater than they could supply, the Corporation, on the advice of the late Mr. J. F. Bateman, Past-Pres. Inst.C.E. in that year, obtained an Act of Parliament, purchased the company's rights for 18,000*l.* and also constructed new additional waterworks at Witcombe, 5 miles east of the city, on an escarpment of the Cotswold Hills, and in 1863 the city was supplied from this source by a 12-inch cast iron main from two impounding reservoirs, having a total capacity of 80 million gallons. The second or lower reservoir was in 1870 enlarged, and a third reservoir constructed, bringing the total capacity of the three reservoirs up to 120 million gallons, which Mr. J. F. Bateman then advised was the limit of the capacity of the watershed of 1500 acres in a succession of dry years.

The rainfall of the district varies from 20·37 inches in 1892 to 42·37 in 1872, and averages about 30 inches per annum.

The Author was appointed Surveyor and Water Engineer in March 1878, and in 1881, owing to dry seasons, it became necessary to give an intermittent supply owing to the great increase in the population taking the water.

The old Roman city walls enclosed about 80 acres, or a square of about one third of a mile on each side. The city was enlarged in the eighteenth century, and in 1874 was 466 acres, and was then enlarged to 1457 acres with a population of about 32,000.

In 1900 the city was enlarged to 2315 acres, and at the census in 1901 the population was 47,955 in 10,098 houses.

The population is now 50,500 in 11,498 houses, and the rateable value on March 31, 1905, was 216,928*l.*

In 1882, Mr. J. F. Bateman was again consulted in reference to an additional supply of water, and recommended tunnelling for half a mile into the face of the escarpment of the Cotswold Hills at Witcombe, to bring back water which followed the dip of strata in a south-easterly direction towards the Thames Valley. This ingenious scheme had to be abandoned after trial borings had been made, owing to legal and other difficulties.

In 1883, on the Author's recommendation, the Corporation installed the Deacon meter system for the detection of waste of water at a cost of 2000*l.* including 20 meters, dividing the city into that number of districts, about 100 additional valves in the distributing mains, and 1200 outside stop taps to service pipes. The result of the working of the system was that by June 1884, the consumption of water was reduced from 32 gallons to 16 gallons per head per day, and it was maintained between that and 20 gallons per head per day until 1896, and since that date at about 22 gallons per head per day, on a total population of 55,000, including the outside population supplied.

In 1891, after Mr. Bateman's death, Mr. William Fox, M.Inst.C.E., was consulted, and he, with the Author, and the late Mr. J. J. Seekings, who was then Mayor, investigated about ten possible schemes for additional water supply, including two from the river Severn, and the one finally adopted, viz., the sinking of a well in the new red sandstone near Newent, 11 miles west of the city.

Accordingly, in January 1893, a boring with the diamond drill 10 inches diameter was started at Oxenhall, near Newent, and an abundant supply was found which overflowed the surface. The boring was continued by the Corporation to 290 feet, but the landowners, thinking to find coal, arranged with the contractors to continue the boring to a depth of 1200 feet, but at this depth the bottom of the Bunter beds of the new red sandstone had not been reached, and the boring was then discontinued. The Corporation deposited plans and applied for an Act of Parliament in November 1893, the only opposition to the scheme being for clauses in reference to wells in the neighbourhood and to the crossing of the river Severn by the 14-inch main carrying the water to Gloucester. The well, which cost 4586*l.*, was commenced in October 1894 and sunk 170 feet into the new red sandstone, 15 feet diameter for the first 60 feet, which was lined with 14-inch brickwork, and 12-feet diameter for the next 90 feet, which was lined with cast iron cylinders 11 feet diameter inside, in 5 feet rings of 8 segments each.

At 145 feet depth out of last ring but one, headings were driven, one in a northerly direction and the other in a westerly direction.

These largely increased the supply to the well, and the contractors, Messrs. Arthur Timmins and Sons, of Runcorn, had to pump 1½ million gallons per day to enable the men to work in the headings. The northern heading is 117 feet, and the western 145 feet in length.

While the well was being sunk, the 11 miles of 14-inch main was being laid, and the covered service reservoir constructed by Messrs. Cruwys and Hobrough, of Gloucester and Birmingham, the contractors for this part of the work. The reservoir is at Upleadon, 3 miles from the pumping station, 150 feet above the top of the well, and 250 feet above O.D., and contains 600,000 gallons; and in 1901 a second reservoir holding 1¼ million gallons was added to the above by the same contractors, from the Author's designs, in concrete. The reservoir is nearly 200 feet above Gloucester Cross. The water was delivered to Gloucester on July 1, 1896. It is raised from the well into tanks under the engine house floor by lift pumps 14¾ inches diameter, 4 feet 6 inch stroke, and double-acting force pumps draw from the tanks and force the water up to the reservoir at Upleadon; thence it gravitates 8 miles to Gloucester.

The 14-inch main is carried over the western branch of the River Severn on a lattice girder steel bridge, 212 feet span carried on screw pile abutments, the latter being used to overcome the opposition of the county authorities, who feared damage to the foundations of Telford's beautiful elliptical stone arched bridge which is close by.

The engines are in duplicate, of the compound vertical condensing type, one on the north side and one on the south of the well, each working a lift pump, which is suspended 130 feet down the well at the bottom of a 16-inch diameter rising main hung upon girders from the top of the well. The pump rods passing down the inside of the rising main are worked by a bell crank lever at the top, driven by a connecting rod from the crank pin of the high pressure cylinder, which is 16 inches diameter, and the force pumps are 10 inches diameter, 4 feet 6 inch stroke, horizontal double acting, and worked from the crank pin of the low pressure cylinder, which is 28 inches diameter.

The engines, pumps, and boilers, which are capable of raising 30,000 gallons per hour, were constructed and erected by Messrs. Summers and Scott, engineers, of Gloucester, who are now putting in larger pumps in consequence of the severe drought of 1904, necessitating both engines working night and day for 3 months;—the larger pumps will give a stand-by under all conditions of the rainfall which affect the Witcombe impounding reservoirs. The engines are arranged clear of the well, so that either lift pump can be lifted out with its rising main by simply disconnecting the pump rods from the bell crank lever. There is an overhead travelling crane for lifting any part of the machinery. The fly-wheels are 16 feet diameter and weigh 12 tons each. Both engines pump into a common air vessel 13 feet high and 4 feet diameter. The cylinders are steam-jacketed with an intermediate heating cylinder, and supported on A frames which also carry the platform and valve gear. Steam is supplied at 100 lb. pressure from three Lancashire boilers 22 feet long by 6 feet diameter, fired with slack coal by Bennis and Co.'s mechanical stokers; the feed-water is passed through a Green's economiser, placed on a by-pass in the flue leading to the chimney, which is 86 feet high. The engines, pumps and boilers cost 5415*l.* The pumping station, built in red brick and forest stone dressings, consisting of engine house 60 feet by 30 feet, boiler house, workshop, etc., cost 3,766*l.* The total cost of the scheme was 45,000*l.*

In 1901 considerable trouble was experienced at the Witcombe reservoirs with the growth of water plants of the *Cara* and *Nitella* group.

These weeds grow at the bottom of the reservoirs wherever light penetrates, and at a very rapid rate, especially during the summer months, when the temperature in the air is over 60° F., and at certain stages of their growth they impart a fishy taste to the water, and although this is in no way injurious to health, it is very unpleasant to the taste and smell, especially when the water is heated. In order to overcome this difficulty, the Author installed, in October 1901, a battery of 10 Bell Bros. mechanical filters at a cost of 5000*l.* or about one-quarter of the total which would have been necessary to establish ordinary sand filters at the reservoirs, which would have necessitated a loss of 50 feet of head in the main going to the city. The Bell filters being continuous in action only create a loss of 2 lb. pressure between the inlet and the outlet of the filter. They consist of 10 steel drums, each containing about 7 tons of Leighton Buzzard sand, through which the water is passed. The filters are washed out 3 times per week by reversing the flow of the water to each cylinder in succession; they can be used with or without chemicals, but from one-tenth to 1 grain of sulphate of alumina per gallon, greatly facilitates the filtration, the result being that the water is sent to the city clear, bright, and in perfect condition. The filters act both bacteriologically and chemically. Mechanical filters have been in use in America for filtering the water from lakes and rivers from which many American towns are supplied. The Bell filter is a very great improvement on the American filters, inasmuch as, in addition to reversing the direction of the water through the filters for cleansing purposes, while this is going on a system of stirring arms are made to revolve by means of an oil engine, shafting and bevel gearing attached to the outside of the filters. This disturbs and stirs up the sand in the filters, so that it is thoroughly washed by the reverse current of water, and it is this method of stirring up the sand which is the great point in the success of cleaning out the filters, as, without the stirring, the current of water is apt to take a direct course between the inlet and the outlet of the drums, without greatly disturbing the whole of the sand. These filters have now been at work for 3½ years, and have made the Witcombe water potable during the hot months of the year, when, in old times, it had frequently to be shut off from the city.

SEWERS.

There is a good natural fall from north-east, east, and south-east, towards the west, while the fall from north to south is very small along the line of the river. The highest points near the city boundary range from 80 to 90 feet above O.D. The northern boundary on the Tewkesbury or Kingsholm road is 38 feet, and south-west boundary on the Bristol road is 36 feet above O.D., while the city quay, where the main outfall sewers discharge, is 32 feet above O.D. The lowest summer level of the river Severn is 20·53 feet above O.D. at the city quay.

Previous to the Public Health Act of 1848, the drainage of the city was into cesspools or into the brooks above mentioned by means of brick culverts laid along ditches emptying themselves into the brooks, and the brooks themselves in process of time had been converted into sewers by covering them over with brick arches.

In 1852, under the powers of the 1848 Act, the city was entirely re-sewered in a very thorough and efficient manner by Messrs. Rammell and Lister, civil engineers, the contractor being Mr. Guest, and provision was made in the sewers then laid down, for their future extension to near the present area of the city. They consist of two main outfall sewers, one draining the northern portion and the other the southern portion of the city, both converging at the city quay, and in 1852 they discharged by a single outfall into the river at 17 feet above O.D. Each sewer was egg-shaped, 4 feet 6 inches by 3 feet diameter, and the outfall was a 30 inch iron pipe until 1886, when the Author constructed the new quay wall, 200 yards in length, and took the opportunity that work afforded to give each sewer a separate outfall, thus giving great relief to the sewers in heavy weather.

The district added to the city in 1875 had previously been in charge of three local boards who were chiefly responsible for the pollution of the Twyver, the Sudbrook, and the Tweenbrook, and in 1875 on the advice of Mr. James Mansergh, Past-Pres. Inst. C.E., the system of 1852 was extended into the added area; but during the construction of these extended sewers, which were of course laid in the streets, the old system of shallow brick culverts which were nearly all at the backs of the houses had to be maintained until the private drains could be relaid and reversed in direction. The old culverts were, therefore, temporarily connected to the new sewers wherever they were crossed, and the Author inherited this curious state of things on his appointment in March 1878, the result being that in the following summer, owing to the nuisance from the new sewer manholes discharging foul gas from the old culverts, he investigated the whole matter, and recommended in 1881 that the 3000 house drains then connected to the old culverts should be transferred direct to the new sewers. The Corporation tried to make the private owners do this, and by 1884 had succeeded in getting 2000 houses re-drained and the city water laid on; on a second report by the Author in that year the Corporation decided to do the remainder themselves under Sec. 23 of the Public Health Act, 1875; the Author completed this work in 1885; an immediate drop of 3 per 1000 occurred in the death-rate, and the complaints of smells from the manholes entirely ceased. Up to this date the by-laws were those of the 1848 Act, which were obsolete, and the Town Clerk and the Author with a sub-committee had been trying for eighteen months, to revise the "Model" By-laws issued by the Local Government Board in 1877, which are familiar to the Members of this Association; but on the plea of uniformity nearly all our proposed revisions were struck out, and we had to adopt the "Model" By-laws as they stood, including the so-called intercepting trap, which the Author has consistently opposed since it was first adopted by the Local Government Board, and as long as this absurd and unscientific obstruction is obliged to be introduced into every house drain, so long will the question of the ventilation of sewers be an unsolved problem.

The two main trunk sewers and branches discharging at the quay, consist of 5579 yards of brick sewers, ranging from 4 feet 6 inches by 3 feet to 2 feet 6 inches by 1 foot 9 inches, and 51,637 yards of pipe sewers ranging from 18 inches to 9 inches, a total of 57,216 yards.

In 1884, by arrangement with the Gloucester Rural District

Council, a joint sewer was laid down along the southern boundary of the city discharging into the river at Llanthony, below the city, consisting of 1354 yards of brick sewers, ranging from 3 feet by 2 feet 3 inches to 2 feet 6 inches diameter, and 6756 yards of pipe sewers ranging from 18 inches to 9 inches, a total of 8110 yards.

On the extension in 1900, the system was further added to by 6879 yards of pipe sewers, ranging from 18 inches to 9 inches diameter, at a cost of 6000*l.*, bringing the total length of sewers in the city up to 41 miles 45 yards. The two large outfall sewers, 4 feet 6 inches by 3 feet diameter, have gradients of 1 in 240 and 1 in 480 respectively for the first 1000 yards from the outfall, and the pipe sewers have generally very good gradients, there being an average fall on the surface of the ground in the directions mentioned above of about 30 feet to the mile. The sewers are all on the combined system, and for some years they suffered from periodical flooding arising from the three natural water-courses which in heavy weather brought a lot of water from the outside area into the city, the Twyver having a gathering ground of 1593 acres, and the Sudbrook 1963 acres outside the city, and in times of heavy rainfall the covered portions of these brooks through the city were surcharged and the flood water overflowed into the sewers, causing great damage and inconvenience. These floods generally occurred at intervals of from five to six years, and on each occasion the surveyor had to report upon the matter and obstructions were removed, but the chief trouble was in connection with the Sudbrook outfall culvert, which passes through the Midland Railway goods yard in the Bristol Road and has its outfall into the canal.

In 1879 the surveyor reported that the only remedy for this was the enlargement of this culvert, which was 500 yards in length and only about 21 square feet sectional area, and it was only after many negotiations between the corporation, the Midland Railway Company, and the Gloucester Wagon Company that the matter was finally tackled, and a new culvert constructed by the corporation with a sectional area of 45 square feet at a cost of 5000*l.*, to which the Midland Railway Company contributed 2000*l.*, the Wagon Company 1000*l.*, and the Corporation the remainder.

The Corporation also laid an 18-inch storm-water drain down the valley of the Tweenbrook, which also runs into the canal, and this, combined with the removal of certain obstructions in the Twyver culverts, has entirely cured the trouble from the overflow from these three brooks. The construction of these storm water outlets greatly relieved the sewerage system, and the Author hopes to hear no more of the flooding of basements from this cause.

The floods of the river Severn which occasionally occur are beyond the control of the corporation, as the river drains an area of 3700 square miles above Gloucester, but they have little or no effect upon the city, as the flooding only takes place in the immediate neighbourhood of the quay as far as the city itself is concerned, but the two channels of the river become one during a flood, and Alney Island is submerged. The highest flood of modern times in the river Severn occurred in May 1886, and rose to a height of 33 feet above O.D. at the quay, that is to say, it was 1 foot above the quay wall. Since then the construction of the Liverpool waterworks at the head waters of the river Severn at lake Vyrnwy has had considerable effect in reducing the flooding of the river.

There is a weir in the western channel of the river just below the upper parting at Maisemore, and another in the eastern channel at Llanthony, 900 yards below the Gloucester quay, and these hold up the water in the eastern channel to its lowest summer level 20·53 feet, the invert of our sewer outfall being 17 feet above O.D., or 3 feet 6 inches below lowest summer level. No nuisance, however, has ever been known to arise from this fact, but the Local Government Board are pressing us to discharge the sewage into the western channel below the weir, so as to get a free outfall; the low water level of the western channel is only one foot lower than the invert of the sewer, and the distance between the two channels is 770 yards, therefore this can only be effected by pumping from 3 to 6 million gallons of sewage per day, and in time of flood the pumps would be drowned. When the extension of the city in 1900 was granted, the Local Government Board made the Corporation promise to consider this question, but they are under no legal liability to carry out the suggestions, as Gloucester is on the tidal portion of the river, the tides going up to Tewkesbury, 12½ miles above Gloucester, and at low water the amount passing over the weir is 300 times more than the dry weather flow of the sewers.

From the report of the medical officer of health for 1904 the death-rate of the city was 14·8 per thousand, and the zymotic death-rate 1·7 per thousand.

MARKETS AND DEPOT.

Gloucester is the centre of a large agricultural district, and markets have been held here from time immemorial. The cattle market was established in its present position in 1821, and enlarged under the Act of 1874, and until 1896 the Corporation depot occupied a corner of the cattle market, but in that year a new depot was built in the Stroud Road and the old depot absorbed in the cattle market. Very large sales of cattle, sheep, pigs and horses are held here on Saturdays and Mondays throughout the year; and recently a fruit market has also been established, buyers coming from all parts of the kingdom to attend the markets.

The Eastgate market was opened in 1856, and provided with a new roof in 1902; the corn exchange was opened in 1857.

The Corporation depot, constructed in 1896, on 1½ acre of land belonging to the Corporation, contains stabling for 30 horses, cart sheds, steam-roller sheds, mess-rooms for the men, blacksmith's, carpenter's, painter's, plumber's and mason's shops, house for general foreman and horse-keeper, general stores, offices, etc. The cost of the whole was 7000*l.*

PUBLIC BUILDINGS AND BATHS.

The other public buildings in the city are:

Municipal Schools of Science and Art,	**opened in**	**1873**
Public Baths, Barton Street,	**„**	**1891**
Guildhall, Eastgate Street,	**„**	**1892**
Public Library, Brunswick Road,	**„**	**1900**
Electricity Works,	**„**	**1900**
Hospitals, Over,	**„**	**1903**

The question of public baths was first discussed in 1875, but remained in abeyance until 1880, when the Author got out the plans for erecting swimming and private baths on the site of the pump rooms at the Spa. This project, however, fell through until the late Mr. Seekings, when mayor in 1890, with the late Mr. J. Platt took up the question. A site was then purchased at Charlton House, Barton Street, for the sum of 1460*l.* An architectural competition was invited which resulted in 60 sets of plans being sent in, which were duly adjudicated upon by Professor Roger Smith of London, the first prize being awarded to Mr. J. Fletcher Trew, of Gloucester; but as the Baths Committee wanted Turkish baths, two swimming baths, a number of private baths, and a steam laundry for the impossible sum of 6000*l.* the plans had to be re-drawn by Mr. J. Fletcher Trew in conjunction with the Author, and the contract was eventually let to the late Mr. D. C. Jones, builder, of Gloucester. The total cost of the buildings and furnishing, exclusive of land, was 12,320*l.* The first and second-class swimming baths are identical in size, being 82 feet 6 inches long and 28 feet 6 inches wide (water area). The building covering each bath is 100 feet by 46 feet internal dimensions. The water is heated by a Cornish boiler 25 feet long and 6 feet in diameter, which discharges steam into the bottom of the deepest part of the swimming baths. The steam from the boiler is also let into tanks on the roof for heating water in the Turkish and six first-class and eight second-class private baths. The laundry is placed over the boiler, so that abundance of steam and hot water can be got for washing towels, bathing dresses, etc., for the use of the bathers. The laundry is not open to the public. The Turkish bath is a very good one, consisting of a dressing room with 12 dressing boxes, three hot rooms graduated from 140°, 180° to 220° F. The shampooing room is kept at a temperature of 105° F., and there is also a large cooling room. The Turkish and Russian bath is heated by a Constantine stove; the laundry machinery is by Messrs. Bradford and Co., Manchester. In 1904, 36,133 tickets were sold, including 4149 at 1*d.*; 2657 free tickets were issued, and the takings amounted to 897*l.* 17*s.* 6*d.* The expenditure, including interest and repayment of loan, amounted to 1956*l.* 12*s.* 1*d.* The excess of expenditure over income was 1058*l.* 14*s.* 7*d.* or about equal to a 1¼*d.* rate.

PARKS AND CORPORATION ESTATE.

The parks and spa pleasure grounds were established in 1861 under a trust deed vesting them in the Corporation, and since then a recreation ground of two acres has been established at Kingsholm in a very populous part of the city; also the Priory recreation ground of 9 acres, and one at Saintbridge, acquired under the extension order, of 6 acres. The Corporation own a large amount of land and other property which is in process of development as a building estate in the neighbourhood of the Stroud Road, a good deal of which is at present let out as allotments at 8*d.* and 10*d.* per lug or perch.

HOSPITALS.

The new infectious diseases hospitals at Over, which were opened in 1903, provide three ward pavilions giving accommodation for 40 beds, and one administrative block. It is situated on about 20 acres of land which were purchased by the corporation for this purpose. The buildings, including furnishing and land, cost 26,000*l.*, and were designed by Messrs. Waller and Son and Messrs. Medland and Son, Gloucester, as joint architects.

ELECTRICITY AND DUST DESTRUCTOR WORKS.

The Gloucester electricity works were opened in July 1900, and the refuse destructor in connection therewith in October 1902. Mr. Robert Hammond, M.I.E.E., M.Inst.C.E., with the Author and Mr. Harry Dancey, architect, Gloucester, were jointly responsible for the electricity works and refuse destructor. After visiting several other towns with a sub-committee, the continuous-current three-wire system was adopted as being the most suitable to this city.

The site of the refuse destructor was chosen, after considerable controversy, because of its central position and the facilities for extension. Before adopting the twin-cell type of destructor, by Messrs. Heenan and Froude, of Manchester, Mr. Robert Hammond and the Author visited all the leading types, and although the one by Messrs. Heenan and Froude was in an experimental stage at Farnworth, near Bolton, Lancashire, they felt that it was capable of being developed into a good destructor, especially suitable to the site at command. Many suggestions were made to the makers, and the result is the destructor as now working.

The regenerator for heating the blast by passing it through tubes exposed to the flue gases is a very great addition to the efficiency of the destructor. The flue from the destructor joins the flue from the Lancashire boilers; and together they pass up the chimney shaft, which is 150 feet in height. In the first instance there were some slight complaints of flue dust escaping from the chimney, but with special attention to the cleaning of the flues there has been no difficulty from this cause for a long time past.

The refuse destructor was opened in October 1902. It was tested in November 1903. The grate area of each pair of cells is 66 square feet, the pair being separated by a low bridge running between them, like the bridge at the back of a boiler, one cell of each pair being charged alternately. The rate of consumption of refuse per hour with one pair of cells was 3435 lb., or 52 lb. per square foot of grate area. Water evaporated per lb. of refuse, 1½ to 2 lb. from and at 212° F. There is a Babcock and Wilcox boiler on the top of each pair of cells, and the average steam pressure during the test was 164 lb. The initial temperature of the feed water was 55° F. The blast is driven by electric fans and is passed through the regenerator, the temperature of the air before passing through the regenerator being 68° F.; and after passing through it 215° F.; the temperature of the combustion chamber ranging from 1524° F. to 2057° F.; percentage of residuals to the refuse, 25 to 30; kilowatts obtained ranged from 120 to 165; units of electricity per ton of refuse, from 80 to 90; tons of refuse destroyed per 24 hours by one pair of cells, 36½.

The refuse is collected three times per week from every house in the city on alternate days, and varies at present from 150 to 200 tons per week. There is therefore no occasion to store refuse for more than two days in any house in the city. The system has many advantages and some disadvantages, the difficulty being to get some of the householders to put out the refuse on each day on which it is collected. They are apt to put it out on the day nearest the end of the week, which makes the collection very irregular, as it is of little use to start the collection before 8.30 in the morning during the winter months, and that makes a great rush to get the collection finished by 12 o'clock noon. Another difficulty is that the receptacles containing refuse are of a very miscellaneous character, consisting of all kinds of wooden boxes, etc., but where the proper portable sanitary galvanised iron bin is used the system works very well.

ROADS.

There are about 45 miles of roads and about 90 miles of footways in Gloucester. The majority of the roads are macadam except on the tramway route, of which there are 7 miles within the city and two miles outside. The tramway route is paved with Welsh setts from Carnarvon, and the centre portion of the city in the neighbourhood of the Cross, both tramway and carriageway, is paved with Jarrah wood blocks.

For the macadam roads Clee Hill Dhu stone has been used for the last 27 years, but for the first coating of the new roads or for the making up of private streets, Chepstow stone is used. The Clee Hill stone is of the basalt formation and the Chepstow is of the carboniferous or mountain limestone formation. A road made with Clee Hill stone, however, makes about one-third the mud of that made with Chepstow stone.

TRAMWAYS AND ELECTRIC LIGHT RAILWAYS.

The horse tramway was laid down in the city in 1879 on the Kincaid system, and this was worked by a company until 1902 when it was purchased by the Corporation for 26,000*l.* and in its place the Corporation have laid down a system of electric light railways, covering 7 miles of route inside the city and two miles outside the city, the latter being under the order granted to the Gloucestershire County Council, but laid down under the same contract by the Corporation who work the line. The electric light railway is equivalent to 12½ miles of single track inside the city and 2½ outside, or a total of 15 miles of single track. Messrs. Alfred Dickinson and Co., of Birmingham, in conjunction with Mr. Robert Hammond, of London, were the consulting engineers for the tramways, Mr. Hammond looking after the generating plant, while Messrs. Dickinson and Co. looked after the track, feeders, and overhead equipment, in conjunction with the Author. The rails are 90 lb. to the yard, 50 feet in length, 6 inches deep, head 3⅜ inches wide, tread 2⅛ inches wide, groove 1 inch wide, guard ⅝ inch wide, flange 6 inches wide, 3 feet 6 inch gauge, double copper bonded with 6/0 S.W.G. and 4/0 S.W.G., paved with 5 inch by 4 inch setts laid upon 6 inches of cement concrete. The rails are fished with ordinary fish plates, 60 lb. per pair, six bolts to each joint, tie bars 8 feet apart, but the joints are not anchored to the concrete in any way. The rails were supplied by the Barrow Steel Co., and the points and crossings by Messrs. Askham Bros., of Sheffield, the contract for the poles was let to Messrs. J. G. White and Co., and the overhead equipment to the British Electrical Equipment Co. The line is worked by 30 cars constructed by the Brush Electrical Engineering Co. The cars hold 18 inside and 23 outside, total 41 passengers. The cars' electrical equipment is by Messrs. Dick, Kerr and Co. The work was commenced by Mr. George Law on November 9, 1903; the first section was opened on May 3, 1904, and the last section in July 1904. The overhead equipment is fed at every half mile from underground cables laid in cast iron troughs filled up solid with bitumen, each feeder pillar being fitted with switches for isolating the length and with telephone communicating with the car depot. The overhead trolley wire is of copper "0" B.W.G. insulated at every pole which are 40 yards apart. The car shed was originally an old saw mill, and was purchased as one of the assets of the old horse-tramway company. There being plenty of land in connection therewith, the Author nearly trebled the size of the buildings, and provided six lines of car sidings with pits, repairing shop for the electric motors, car repairing and paint shop, smiths' shop, stores, offices, and mess room for the men, the cost of the additions and alterations being 5030*l.* 14*s.* 7*d.* The total cost of the electric light railway work inside the city was 128,436*l.* 13*s.* 7*d.*

The rateable value of the city was 220,000*l.*, and the rates, owing largely to the education rate, were up to 7*s.* in the £.

GLOUCESTER ELECTRICITY WORKS.

By WALTER J. BACHE, M.I.E.E., Electrical Engineer.

The Gloucester Municipal Electricity Works were authorised by a Provisional Order granted in 1896, in response to an application by the Corporation, who lost no time on the receipt of the Order in taking steps to erect their works. In 1897 the Council instructed Mr. Robert Hammond to prepare a preliminary report, and in the following August they decided to establish Electricity Works in combination with a Refuse Destructor, on the lines advocated by Mr. Hammond, and instructed him to draw up a detailed scheme. It is interesting to note that the present arrangement of the works was designed eight years ago, and although this is a considerable period in the history of electricity supply, the works may be considered, even now, up-to-date and of modern design. It would not be difficult to find works designed later than 1897 of which the same could not be said at the present time.

The scheme submitted provided for a three-wire, direct current low tension system of generation and distribution, with Lancashire boilers, two generating sets, each consisting of two dynamos in tandem direct coupled to a high-speed engine, and a triple concentric network fed at various points by triple concentric feeders.

The architect's work was placed in the hands of Mr. Harry A. Dancey, of Gloucester, who carried out the ideas of the engineer in a successful manner, and provided a very suitable and pleasing set of plans.

The combined electricity works and refuse destructor were designed as one scheme, but owing to delays in obtaining possession of the site, and other causes, the electricity works were running two years before the completion of the refuse destructor.

The selection of a suitable site for the works demanded careful consideration from many points, as the conditions vary greatly as regards network in the residential and manufacturing parts of the same town. The general characteristics have to be reviewed, the location and probable lamp density of the more important areas of supply must be estimated, and the immediate vicinity of the suggested site must be examined in order to avoid placing the works where a nuisance may be created. Facilities for obtaining coal and water for condensing are essential to economical working, and require due consideration. The terms on which the site can be acquired, and the cost of rendering it suitable by excavation, removal of old buildings, etc., will also have a bearing on the choice of the site.

All these considerations were carefully gone into in the Gloucester works, with the result that the site is particularly well chosen. The works are situated in the south-west part of the city, and are most conveniently placed, within 600 yards of the Cross, which is the business centre. They are also close to the docks, which afford an abundant supply of water for condensing purposes, while the railway lines in the docks provide connection with the Midland and Great Western railways. At present there is no siding into the works, but should one be required in the future it could be laid down without any difficulty.

The ground on which the buildings stand consists of "made soil," and during the excavations for the foundations many traces of the Roman occupation were brought to light. The foundations are carried down to the blue lias clay, which was found at a depth of 11 feet below the surface. Underneath the condenser pit the contractor encountered a portion of the old bed of the Severn, and two underground water-courses traverse the site diagonally from north-east to south-west, and are separated by a distance of about 30 to 40 feet. A bed of quicksand in the boiler-house and a series of extraordinary pockets or depressions in the lias clay under the refuse destructor and the chimney stack added to the builder's difficulties, and called for special methods of construction.

The buildings are of brick with stone dressings, and consist of two large bays for the boiler-house and engine-room respectively, a small bay containing the test room and switch-room with the battery room over, and a well arranged suite of offices and stores.

The refuse destructor is placed at a right angle to the boiler house, and between the latter and the chimney stack. Provision has been made for the extension of the engine room and boiler house.

The chimney stack is 150 feet high from the ground level. It rests upon a solid bed of concrete, 30 feet square and 10 feet deep. The brickwork footings are 6 feet deep. The chimney is built square for the first 37 feet, and from this height to the top it is octagonal in shape. The internal diameter is 6 feet throughout, inside the firebrick lining, which is carried to a height of 60 feet, with a 4½-inch air space between the lining and the outer brickwork. The chimney has an ornamental moulded stone cap. The theoretical capacity of the chimney is approximately 1100 H.P., and it accommodates six boilers at the present time, which, if all were steaming together, would exceed its full capacity. Three new Lancashire boilers are being laid down this year, and it is probable that when the next boiler extension is made it will be necessary to provide for an increased draught. It is interesting here to compare the relative costs of the various methods of obtaining draught for boilers on the H.P. capacity basis as above stated. Taking first the cost of an ordinary brick chimney, of which Gloucester is a typical example, the price may be stated at 1500*l.* An Alphons Custodis chimney of the same capacity would cost about 900*l.* Coming now to mechanical draught, and assuming that conditions similar to those in Gloucester have to be met, the capital outlay, including the necessary short steel stack, is only about 350*l.* Forced draught has many advantages over induced draught, for the former has only to push the air through the fire, while induced draught has to do this and also to draw the products of combustion along the flues, and thus obviously requires more power. Further the induced draught fan has to deal with gases at a high temperature, and containing a good many destructive constituents. Therefore its life must be considerably shorter. Again, the induced draught fan sucks in cold air through every crack and crevice in the boiler setting and elsewhere. Forced draught, on the other hand, tends to seal up such cracks with flue dust, or make them permanently or aggressively visible by forcing smoke through them.

As regards annual upkeep, taking the cost of a brick chimney at 1500*l.*, and allowing 6½ per cent. for interest on capital expenditure, depreciation, etc., an annual expenditure will be incurred of 97*l.* 10*s.* For a forced draught system the above charges may be taken at 8 per cent., which on a capital expenditure of 350*l.* means an annual payment of 28*l.* The cost of running the motor which would be required to drive the fan, and using 54,000 units per annum at ¼*d.*, is 56*l.* Thus the forced draught system is 13*l.* 10*s.* cheaper, annually, than the chimney stack. This does not take into account the other advantages, such as greater control over fires, and therefore economy in coal consumption.

If the air be heated on its way to the fires no additional expense is incurred, except a slight increase in the capital cost, while the conditions under which combustion takes place are so much improved that a reduction in the coal bill amounting to 7½ or even 10 per cent. may be effected.

The boiler house is 61 feet in length, 48 feet wide, and 41 feet in height, and contains at present three boilers, each 30 feet long by 8 feet in diameter, and one 30 feet long by 8 feet 6 inches. The smaller boilers have a grate area of 38 square feet and a heating surface of 1015 square feet, while the larger one has 37 square feet of grate area and a heating surface of 1160 square feet. The respective evaporations are 6500 and 8000 lb. of water per hour.

The Lancashire boiler is eminently suitable for Gloucester, which possesses a clear, bright atmosphere, and experiences few fogs. There are, therefore, no sudden demands for steam, such as occur in many manufacturing towns. Where these rapid demands are prevalent the water-tube boiler undoubtedly possesses advantages, but for ordinary steady conditions of working it cannot compare with the Lancashire type, which has the very considerable advantages of low first cost, economical steaming and low repairs costs, not to mention the freedom from anxiety it insures for the engineers who have to work the boilers, which cannot be said of the water tube boiler with its rapid evaporation and small water space.

All four boilers work at a steam pressure of 160 lb. per square inch, and contain the usual fittings, of Hopkinson's make. The main flue is provided with a Green's economiser, having 192 tubes in two sections and a by-pass flue. The scraping gear of the economiser is driven by a 5 k.w. Bruce-Peebles enclosed motor. Previous to passing through the economiser the feed-water is heated in a Berryman feed-water heater. The latter is operated by the exhaust steam from the auxiliary plant.

The pump-house is situated at the west end of the boiler-house, and contains two pumps, one an Evans' compound double-acting fly-wheel pump, the other being of Messrs. Weirs' manufacture, and of the type associated with their name.

Both pumps draw their water direct from the feed-tank, which is placed above the pump-house, and has a capacity of 3500 gallons. The feed-water consists of a mixture of canal water and condensed steam, and gravitates from a branch on the condenser discharge pipe to a sump near the boiler-house. From the sump it is lifted through a Mather and Platt feed-water filter to the feed-tank. The water is raised from the feed-sump and elevated to the tank by means of a 1½-inch centrifugal pump driven by a 1½-H.P. motor, also of Mather and Platt's make. The motor is started and stopped automatically by a patent switch, operated by the water level in the overhead tank. The action is very simple. A wooden float in the tank is connected by a chain to the switch lever, the chain passing through a slot in a flat lever, with an iron weight on each side of it attached to the chain. When the water in the tank is low the float falls, pulling the chain and the lower weight, which raises the switch lever and starts the motor. When the water rises to its normal level again the top weight pushes the switch lever down and stops the motor.

The main steam-pipe in the boiler-house is 8 inches in diameter, increasing to 10 inches, the connections to each boiler being of 6 inches diameter. Water pockets are fitted at the junction of each engine branch with the main steam-pipe. There are no steam traps on the main range, or, indeed, in the station, which is, perhaps, a unique feature. The feed system is duplicated, so that in the event of a breakdown to the hot feed pipe, or the economiser, the boilers could be fed through the cold feed pipe. A 3-inch auxiliary steam range supplies steam to the condensing plant, pumps, etc.

All the steam and exhaust pipes are lagged with removable magnesia covering, and the pipe joints are fitted with Lonsdale's removable steel flange boxes packed with felt.

The engine-house is 96 feet in length, 37 feet wide and 38 feet high. The interior walls are built in buff bricks, with a dado of brown glazed bricks. The floor is laid with the Papyrolith Co.'s patent paving. The switch-room runs along the south side of the engine-room, and is open to it. The condenser pit is situated at the west end of the engine-room. The chief engineer's and chief assistant's offices overlook the engine-room, and access to them from it is provided by means of an iron staircase.

A 10-ton overhead travelling crane spans the engine-room. It was made by James Spencer and Co., and is operated by hand from platforms running the whole length of the crane girders.

The engine-room contains at present three lighting and two traction sets, a balancer, a reversible booster, and a negative booster.

The lighting sets consist of one 250 I.H.P. compound, two-crank Belliss engine direct coupled to two 75 kilowatt Silvertown dynamos of inverted horseshoe type; one 500 I.H.P. triple expansion three-crank Belliss engine coupled to two 150 kilowatt Silvertown dynamos of the same type as the smaller set; and one 500 I.H.P. triple expansion three-crank Willans engine direct coupled to two 150 kilowatt Mather and Platt four-pole dynamos.

The dynamos are all shunt-wound to give from 220 volts at no load to 250 volts each at full load. The first two generators have smooth drum bar armatures, small commutators, and copper gauze brushes. When the traction plant was designed the possibility of adapting the existing lighting sets was considered, but the design of the sets rendered them totally unsuitable for this work.

It may be pointed out that although the smaller engine was designed to work with a steam pressure of 130 lb., it has never worked under these conditions, as it always takes its steam from the main range, at a pressure of 160 lb. This adaptability speaks well for the soundness of manufacture.

The two traction sets, which are of equal size, each consist of a three-crank, triple expansion Willans engine, of 300 I.H.P. direct-coupled to a 200 kilowatt multipolar generator of the General Electric Co.'s make. The latter are compound wound to give from 500 volts on open circuit to 600 volts at full load. They are also arranged so that the series winding may be cut out of circuit, and the machines are then capable of running on the lighting load if required.

A reversible booster, used in conjunction with the battery is placed in the engine-room. It is of Crompton make with Crompton-Macintosh winding, and is coupled in series with the battery, the object of the combination being to take the peaks of the load, and thus by equalising the work on the generator, it has been possible to instal a machine of smaller output than would be required if the generator had to deal with the whole of the fluctuations in the load. The regulation is performed automatically. The motor side of the combination takes its current from the lighting bus bars at a pressure of from 440 to 480 volts, and the generator side is capable of giving an output of 120 volts charging and 60 volts discharging with a maximum current of 300 amperes for 10 hours.

The negative booster is placed near the reversible booster, and consists of two open protected-type, four-pole machines, direct-coupled, and mounted on the same bedplate. The motor side takes its current from the traction bus bars at a pressure of from 500 to 550 volts, and the dynamo side can give, at constant speed, an output of 400 amperes at 8 volts continually.

The battery consists of 260 cells of the E. P. S. Co.'s "P," or traction type. It is connected in series with the reversible booster, and in parallel with the generators.

The switch-room, as mentioned above, is open to the engine-room, but its floor is raised 4 feet, and thus an uninterrupted view of the machinery, etc., is provided for the engineer-in-charge and the switchboard attendant. This is a distinct improvement on a gallery, owing to the absence of a long flight of steps, as, in case of emergency, the engineer can be in the engine-room with the least possible delay. The switch-room contains the lighting and traction switchboards. The former was made by Crompton and Co., and is of handsome appearance. It is divided into three main panels, the neutral and instrument panel in the centre with the positive and negative panels on the right and left respectively. The board is constructed of slate slabs fixed in a wrought-iron framework, which rests on a plinth of glazed bricks.

Each set of two dynamos is coupled in series by a lead from each machine taken to the neutral bar, and the two outer leads are run to their respective sides of the board. Thus each set is self-balancing. Modern practice in three-wire systems is to run single generators, and obtain the balance of current by means of small units which are either steam dynamos or motor generators. This method may be preferable in large stations, where there are several sets running, but in small stations where the out-of-balance current is comparatively light, the advantage lies distinctly with self-balancing sets both from an economical and working point of view. The annual cost of running separate balancers is probably more than the interest on the additional capital outlay necessary to provide self-balancing sets, and in case of breakdown the result is usually a total failure of supply. This is not the case with self-balancing sets, as should one machine break down, the other can usually maintain its own supply until another set can be switched into circuit, and thus only half of the town is in darkness. All the dynamos are coupled up to the bus bars on both sides of the board, through minimum current automatic cut-outs, designed to break circuit when the current falls below 10 per cent. of the full load. Duplex fuses are also inserted with two-way single pole switches. In circuit with each dynamo is a Crompton shunted ammeter, and a dead-beat voltmeter is common to all the machines on each side of the system. The shunt regulating switches and shunt breaking switches are placed on the panels below the instruments. The feeders are taken off the top of the board. Each has an ammeter and a two-way switch with quick-break action, and a duplex fuse. Below the feeder instruments are the vertical dynamo and feeder bars, which are connected to the main bus bars, at the back of the board, by screwed gun-metal plugs.

In the centre panel are the Kelvin voltmeters, for pilot wires and main station bus bars.

The neutral bar is "earthed" by a lead taken to the intake tank. In circuit with this connection is an automatic cut-out. It is arranged to short-circuit the ammeter when the earth current exceeds 10 amperes, leaving a direct connection from the middle wire to earth.

The traction switchboard, which is also constructed of slate, contains seven panels, the Board of Trade panel being placed in the centre with the three feeder panels on the left and the battery and two generator panels on the right. Each generator panel contains a reverse current circuit breaker, designed to break circuit on the reversal of the current to the extent of 10 per cent. and in this event only. An ammeter, a single pole main switch, and a double pole change-over switch, are also pro-

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vided. The latter is designed to enable the machine to be coupled either to the traction bus bars as a compound machine, or to the lighting bus bars as a plain shunt machine. There is an equaliser switch on each machine for paralleling.

The battery panel is arranged in a very similar manner, but maximum breakers are used instead of the reverse current type.

The Board of Trade panel contains the usual instruments, which are necessary to carry out the various tests required by the Board. They consist of the main ammeter, drop voltmeter, pilot switch, leakage current ammeter, and the shunt for the recording earth return ammeter.

The resistance cellar is below the switchroom and contains the shunt-regulating resistances, feeder meters, etc.

The exhaust steam from the engines passes through a 16-inch main under the engine room floor to the condensers, of which there are three, all of jet type and each capable of dealing with 10,000 lb. of steam per hour. The two original sets are of Blake Knowles make, and consist of compound engines, driving the air and circulating pumps direct. The third set, which was erected in 1904, was made by Summers and Scott, of Gloucester and consists of a compound fly-wheel engine, driving air and circulating pumps of Edwards' type at a speed of 105 revolutions per minute. All three condensers are fitted with an automatic brake vacuum, making it impossible for the injection water to back up into the exhaust main.

An automatic atmospheric valve is connected to the exhaust main for relieving the back pressure on the engines in the event of a breakdown to the condensers, or for running non-condensing if required.

The condensing water is obtained from the canal basin.

The intake pipe is placed at a depth of 3 feet below the lowest summer level of the canal. The water gravitates through 18-inch cast-iron pipes to a large screening tank, from whence it is drawn by the circulating pumps. This tank is 14 feet long by 8 feet wide and 15 feet in depth, and is placed outside the engine room. It is constructed with brick walls 14 inches thick, resting on a concrete foundation. The tank is divided by a wrought iron screen, the intake and suction pipes being on opposite sides of the screen. The screens are in duplicate. The condensed steam and injection water is discharged through 18-inch pipes, with a fall of 1 in 76 to the opposite corner of the basin. An overhead tank has been fixed near the screening tank, into which water is pumped by a 1½-inch centrifugal pump driven by a 2-H.P. British Thomson-Houston motor. The water so raised is supplied by the works to the Streets Committee for street watering purposes at a charge of one penny per van load.

There are 40 miles of cables laid, all on the "solid" system.

The feeders and distributors are of triple concentric type with the neutral "wire" outside. They are laid in cast-iron troughs, and are surrounded with insulating compound. The arc cable, of which there is 15½ miles, is composed of a lead-sheathed, armoured, single 7/16 and 7/18 conductor laid direct in the ground. All the original cables, connections, junctions, etc., were made by Messrs. Callenders. Since the cables were laid we have improved the network by dividing it into sections, each supplied by one of the existing feeders, and linking these sections together through suitable fuses. The Board of Trade are now asking for this to be done in all low tension networks. In our case on more than one occasion it has prevented us having a serious breakdown of the system.

Owing to the heavy and rapidly increasing load in the centre of the town, it has been found necessary to construct a sub-station at the Cross, into which all three feeders passing that point are run. By this alteration the load on this district is carried by cables equivalent to a 1·2 square inch feeder. The sub-station is built underground, and is 12 feet 6 inches long, 9 feet wide, and 7 feet 6 inches in height. It is built of brick-work, lined with glazed bricks, with a damp course of "Tenax" 1 inch thick in the walls and floor. It is well ventilated by means of an upcast shaft and small motor fan, the fresh air inlet being an ordinary manhole cover at the pavement level.

A neat switchboard by J. G. Statter and Co. is fixed in the sub-station, fitted with the necessary instruments. The total cost of the sub-station was 340*l.*

Gloucester is exceptionally well provided with arc lighting, there being a total of 175 lamps installed. Fifty-two of these were included in the original scheme, the remainder were erected in 1904 to provide efficient lighting along the whole of the light railway routes within the city.

The lamps are arranged in circuits of nine on 440 volts and of four on 220 volts. Each lamp base is fitted with an automatic cut-out and resistance to maintain the current should any lamp fail. The lamp columns are 20 feet high from the ground level.

The lamps are suspended by steel wires and are lowered for trimming and repairs by means of a winch fitted in the base of the columns. An automatic safety catch prevents the lamps from falling, should the suspending wire break. The lamp circuits are operated by switches placed in the base of the column of each end lamp on a circuit, and automatic time switches are now being experimented with and will be adopted, if proved successful.

Each alternate lamp is switched out at midnight.

There are one or two groups of incandescent lamps installed in side streets, but owing to the keen competition of the local gas company the revenue from each is extremely small, and at the present time it hardly pays us to push their extension.

The method of charging consumers is the maximum demand system, and Wright's indicators are used. The charge for lighting is 6*d.* per unit for any number of units up to the equivalent of 100 hours use per quarter of the maximum demand recorded by the indicator, and 2*d.* per unit for all consumption during the quarter beyond the above. The charge for motive power is 3*d.* and 1½*d.* per unit respectively.

The capacity of the station plant is 1150 kilowatts, of which 400 are for traction purposes, and allowing one spare set of 300 kilowatts, the net available capacity for lighting stands at 450 kilowatts, which is equivalent to 15,000 8-c.p. lamps.

Some idea of the increase in the demand for energy may be obtained from the fact that in December 1900 the total equivalent number of 8-c.p. lamps connected to the mains was only 12,000, whilst there are now about 40,000, or about 2⅔ times the available capacity of the plant. The number of consumers has, in like manner, increased from 100 to 460.

The load factor is 16·6, with a maximum load of 720 kilowatts.

The cost of production for the year ending 31st March, 1905, is given below. It will be found to compare favourably with other stations of similar size:—

Coal	·35
Oil, waste, water, and stores	·02
Wages	·21
Repairs and maintenance	·15
Works cost	·73
Rents, rates and taxes	·08
Management, office and legal expenses	·19
Total cost per unit sold	1·00

Owing to the rapidly increasing demand for energy, it was decided at the close of the past year to lay down large extensions to the plant, and these are now under construction. They consist of three Lancashire boilers, each 30 feet long by 8 feet 6 inches in diameter, fitted with downtake superheaters; a 600 kilowatt steam generator; an electrically-driven surface condensing plant to deal with 30,000 lb. of steam per hour; an electrically-driven feed pump; and the necessary extensions to the pipework, including a new economiser section; also the necessary additions to the boiler house to accommodate the new boilers; and extensions and alterations to the refuse destructor buildings, giving a greatly increased storage capacity.

REFUSE DESTRUCTOR.

The construction of the refuse destructor has been dealt with by Mr. Read, the City Surveyor, in his paper, but it may be briefly stated here that the destructor consists of two "twin" cells of "Heenan" type, each with a grate area of 66 square feet, or 33 square feet per cell. The Babcock boilers are placed above the cells, the combustion chambers intervening. Each twin cell was designed to deal with 25 tons of refuse per day, but the quantity dealt with often exceeds 30 tons per day. The large hoppers as originally installed were not found satisfactory, and we have replaced them by small hoppers, holding about 5 cwt., with an iron door between the bottom of the hopper and the cell. This door is counterweighted, and is operated by a lever worked by the charger, on the tipping platform. When burning the normal quantity of refuse, charging is performed about every quarter of an hour. A fireman stationed on the clinkering floor, drags the refuse on to the grates and distributes it by means of a long rake. Two men are employed per shift of 8 hours, but when the amount burnt exceeds 25 or 26 cwt., an extra hand is required to assist the fireman. The wages of these men are 5½*d.* and 6*d.* per hour respectively.

The "Howden" system of forced draught as fitted is a very successful feature of the plant. The temperature of the air in the hot-air chamber is about 220° to 230° F., with a draught equal to 2 inches on the water gauge. The motors and fans supplying the air, work exceedingly well in spite of the trying conditions under which they are operated, and have cost very little for repairs. From tests which have been carried out on the plant the temperature in the combustion chamber has been proved to exceed 2000° F., and an evaporation of 1·5 to 2 lb. of water per pound of refuse burnt was obtained with feed water at a temperature of 212° F. The steam pressure is maintained constantly at 160 lb. The clinker is of very fair quality, and amounts to about 25 per cent. of the weight of refuse consumed.

Troubles, such as are bound to exist in a brickwork furnace, working at such high temperatures, have been encountered from time to time. The repairs usually consist of renewals of the fire-brick work. It may be interesting to note here, one of the most serious defects which has occurred, viz., the fusing and consequent failure of the steel joists carrying the brickwork above the entrance to the cells at the bottom of the refuse shoots. These were removed and brick arches substituted. The Author is of the opinion that metal should not be built into brickwork exposed to great heat, as the brickwork tends to radiate the heat into the metal, which, in the case of steel greatly weakens its strength, even if fusion does not occur.

DISCUSSION.

The PRESIDENT: I should like to have the privilege of proposing a hearty vote of thanks to Mr. Read and to Mr. Bache for preparing these two excellent papers for discussion. Taking Mr. Read's paper first, there are one or two points I would like briefly to refer to. With regard to the number of houses to population, it cannot be said at the present time that Gloucester is troubled with overcrowding. The average population comes out a little below 4½ persons per house. On the question of water supply, I congratulate the city of Gloucester, and particularly, Mr. Read, the able engineer, on having reduced the consumption of water from 32 gallons to 22 gallons per head per diem. I think that is a great achievement; due to the installation of the Deacon meter. I may say, from my own observation during my sojourn here, I have ascertained that there is no restriction on the supply. In the hotel in which I stayed last night, there was plenty of water; there is no restriction to a flush of two or three gallons, but, notwithstanding this, the consumption is only 22 gallons per head, which is very satisfactory, especially in view of the fact that a constant service is maintained. Then with regard to the intercepting trap. Dare I mention that in Gloucester ? and in the presence of Mr. Read? We know how intensely he dislikes the intercepting trap; but on the other hand, there are differences of opinion. I do not mind candidly confessing that I hold a different opinion, though I do not mind saying that it is a choice of evils. I notice there is a reference in the paper to Turkish baths. I am very pleased to find that Gloucester possesses Turkish baths, because I think they are a luxury for any town to possess. I notice that the temperatures range from 140° to 220° F., but as one who indulges now and then in the luxury of a Turkish bath I suggest that a better range of temperature would be from 125° or 130° to 260° F. The cost of the infectious diseases hospital at Over works out at about 650*l.* per bed, which seems to be a very high figure. With regard to the collection of house-refuse, I understand that receptacles of all sorts and sizes are put out in the streets pending the arrival of the Corporation ashmen. I deprecate that system. I think it would be better for the men to go round fewer times in the week and collect from the backs of the houses than to have the refuse put out in an unsightly manner in the front. Mr. Read has referred to the roads but does not give the cost of maintenance. I would like him to give us the cost of maintenance of both main and district roads.

Mr. A. D. Greatorex: I have much pleasure in seconding the vote of thanks to Mr. Read and Mr. Bache for the very able papers they have given us to-day. With reference to the collection of refuse from the houses, I think the citizens must be very fortunate to have their refuse collected so often, but I quite agree with the President that it is not at all nice to see receptacles of one kind and another placed outside the houses, and it would be better to have some other system if possible. Mr. Read has been very fortunate in getting the connections made with the drainage of the 2000 houses, at the cost of the owners. As regards the infectious diseases hospital, the cost per bed does seem rather high. With regard to Mr. Bache's paper on electric lighting, I would like him to give the cost of street lighting per lamp.

Mr. W. Harpur: In reference to the collection of house-refuse, I am sorry I am not of the same opinion as the President.

I think the oftener the collections can be made the better. If they can be made daily, so much the better for the health of the inhabitants—rather than keeping unwholesome refuse upon the premises of householders. I would like Mr. Read to explain what he means by the statement that "another difficulty is that the receptacles containing refuse are of a very miscellaneous character, consisting of all kinds of wooden boxes, etc., but where the proper sort of sanitary galvanized iron bin is used, the system works very well." I do not see that it makes any difference that the receptacles are of different shapes and sizes, unless of course they are too large and heavy for the men to lift into the carts. The best way in my opinion to prevent having unsightly receptacles with refuse about the streets in the morning, is to collect the refuse at night. At Cardiff, residents put their receptacles out at night when going to bed, the carts go out at midnight, and in the morning residents take in the empty boxes. By 10 or 11 o'clock the following morning, the streets are swept up and clean, and you do not have these refuse boxes about the streets throughout the day causing so much untidiness and litter.

Mr. Norman Scorgie: I stand here having probably a longer acquaintance with Mr. Read than any other person in the room. Mr. Read has told us that he commenced his duties in Gloucester in 1878, and I became associated with him in that year, being his first pupil. I can well remember the principal works carried out here between 1878 and 1883. Notably the difficulty experienced with the water supply and the attempt to get an augmentation of the supply by means of tunnelling at Witcombe. The supplementary works at Newent are since my time. I congratulate him on the connection of the old house drains of 2000 houses with the new sewers, which I presume was done at the expense of the owners. That is a thing which very few of us could get done, and Mr. Read is to be heartily congratulated because, assuming that those connections only cost 10*l*. a house, it meant the saving by Mr. Read of 20,000*l*. to the town. I know Mr. Read's objection to the intercepting trap. If we were private practitioners, we might hold different opinions on that question. The province of the authority is to ventilate the sewers, while the duty of the householder is to ventilate his own drains, and I do not think we should endeavour to shirk our duty by getting someone else to do what we have a statutory obligation to undertake. As regards the baths, it is stated that 2657 free tickets were issued last year. I should like to know how those tickets were distributed, whether through the medium of members of the council, or by the Charity Organisation Society, or the religious denominations. I take it that the tickets that were sold refer to the whole of the baths, and not the Turkish and Russian baths alone. It is somewhat ambiguous in the paper. I agree with Mr. Harpur that the oftener house-refuse can be collected, the better it is for the health of the district. At the same time, I disagree with putting receptacles out on the pavement either by day or night. If Mr. Harpur will only travel to Glasgow, where they put the refuse out at night and see the condition of the streets after 10 o'clock, he will alter his opinion as to night collection. The people at Cardiff must be a very law abiding set not to upset the boxes when they are put out in the streets at night, particularly the young hooligans. Dealing with the roads, I should like to know the reason for using Chepstow stone for the first coating of new roads and the making up of private streets. I presume it is done on the score of expense, but it is a well-known fact that after a street has been made, the responsibility of subsequent maintenance becomes the duty of the authority, and I hold to make up the street with an inferior material to save the abutting owners some part of the initial expense is not a sound municipal policy, because under these circumstances the subsequent maintenance becomes a charge on the rates at an earlier period than it should. I think, if you use Clee Hill Dhu stone subsequently, you should employ it in the first instance, for the reason previously mentioned. I should like to support the vote of thanks to Mr. Bache. Mr. Bache tells us the works cost of electricity is 1*d.* per unit, but he does not tell us the price he gets for public or private lighting; also that they have got 175 arc lamps installed, but what is paid for the lamps is not mentioned in the paper. I am told that the 10-ampere lamps are charged 18*l.* per annum, the 7-ampere lamps 13*l.* 10*s.* and the 5-ampere lamps 11*l.* 10*s.* The 5-ampere lamps are somewhat smaller than I have known to give satisfactory results for arc-lighting, and probably Mr. Bache will express an opinion as to whether they give equally satisfactory results to the Brockie-Pell 10-ampere. Assuming that the electricity undertaking had been under a private company, would the council of Gloucester have installed

175 lamps and been their purchaser at the rate before mentioned, or has it only been done because you are purchasing from yourselves? It is a point often lost sight of in public lighting. Whatever public lighting costs is a permanent load upon the rates, whether it be purchased from the council or from a public company, and it seems to me that the installation of arc-lighting in the streets has cost the ratepayers about an additional 1*d.* in the pound. It cannot, however, be said that it was done because it was necessary to light those roads along which the tramways run, because the tramways extend beyond the city boundary where no such system of lighting is employed. Therefore, if it were absolutely necessary to have arc-lighting for tramway purposes, either the trams ought to have stopped at the city boundary or the lamps should have been placed along the whole route. As regards the destructor, we are told that the wages of the men are 5½*d.* and 6*d.* per hour, two men working on a shift of eight hours. What is the total cost of destroying the refuse, either excluding or including the capital charges; and also, is the destructor worked as a part of the electric light undertaking as it should be, and the electricity department paid so much per ton for destroying the refuse, and making what they can out of it. It is a mistake to manage the dust destructor department by allowing the electricity people to spend money provided by another department out of the rates. They should take the refuse at a fair amount per ton and make what they can out of it, instead of charging the Public Health Department whatever they make the cost come out at, and crediting the Public Health Department with what they make the steam come out to. The electric engineer would then endeavour to use as much steam as he possibly could from the dust destructor so as to save his coal bill. He is now paid 6*d.* per ton of refuse and the cost of destroying it does not concern him. That should be altered. Therefore, I should like to know the cost of the burning of the refuse, and to what extent the Public Health Department benefit by the electricity works using the steam, which is generated by the heat from the destroying of the refuse.

Mr. A. P. I. Cotterell: I have been very much interested in reading the papers and join in congratulating the Authors. Personally I am very interested in visiting this ancient city under the present circumstances, and seeing what is going on in it from the municipal point of view. I was very pleased to notice the way in which Mr. Read, in the introduction to his paper, alluded to the origin of the city. There is little doubt that the facilities which existed in regard to water supply and water carriage were responsible for the origin of Gloucester as a city, and it is noteworthy that to similar reasons is to be ascribed the coming into being of many other cities in the kingdom. The history of the city's water supply seems to be an extremely interesting one, and particularly in regard to the turn-about—which has taken place in Mr. Read's *régime*—from a spur of the Cotswold Hills in the eastern direction to the Newent district in the west. I think Gloucester has done a good thing by turning round, and Mr. Read and the city are to be congratulated that the tunnelling proposed by Mr. Bateman at Witcombe was not carried out, because it is very unlikely that an adequate supply of water could have been obtained there. The boring at Newent is interesting because it is an exceptionally placed geological neighbourhood. Apparently, from the section exhibited, the boring of the well passed entirely through the Triassic formation. If I am not mistaken, the Archæan or Silurian beds are only a short distance off. The section shows the passage through three or four thin beds of conglomerate, but it does not appear as if the boring is in the conglomerate base of the Trias. We know that in the midlands the Bunter beds are the water-bearing strata, and the place where most water can be safely obtained; but in this part of England the Bunter beds seem to have run out—at any rate they do in the neighbourhood of Bristol—and I should like to know if they appear in the neighbourhood of Gloucester. I know how uncertain water supplies in the marl are, so that I cannot think that they have tapped this formation. While speaking of water I would like to mention to the meeting a very interesting set of experiments which my friend, the borough engineer of Newport, has just carried out. He was having great trouble from the growth of weeds of the smaller varieties in the reservoirs, and he has most successfully treated them by the addition to the water of cupric sulphate, which I thought a rather risky experiment. The effect of it has been to entirely clear the reservoir and mains, and to save the town a sum of over 2000*l*. I do not know whether this has occurred to Mr. Read, but it is very clear that if the weeds can be got rid of so cheaply, it is worth considering, especially as I am assured that the addition of cupric sulphate, if carefully done, does not damage the water for potable purposes.

Mr. E. H. CRUMP: I should like to ask Mr. Read a few questions about the water supply and well at Newent. With regard to the well at Newent, I find that headings had to be driven in order to obtain an increased supply. At Hinckley we have a similar supply from the same strata, and unfortunately when the well was sunk, headings were not driven. It is no uncommon thing for the water in this kind of strata to diminish in quantity after pumping a few years. Our supply has diminished, and I would like to know what the cost of driving the headings was, the addition obtained to the supply, and whether there has been any subsequent diminution of the supply. Mr. Read does not mention if he has any main roads in the district, and if so, what the county council allow him per mile.

Mr. P. R. A. WILLOUGHBY: With reference to the collection of house-refuse I should like to know whether it is done by direct labour or contract. If it is done by direct labour I would like to know how Mr. Read disposes of the horses for the remainder of the day, as horses are more required for town work in the early morning than later in the day. I am also a disciple of Mr. Harpur in believing in a daily collection of house-refuse. As to the disconnecting trap a lot of trouble often arises from the inaccessible places in which the disconnecting traps are placed. If builders could be persuaded always to place an inspection chamber on the drain in a place easy of access, a great many of the objections to the intercepting trap would be removed. As regards the wood paving I should like Mr. Read to state what he considers to be the life of jarrah wood, and whether there is much loss from openings in the streets. In Pontypridd we have adopted soft wood, and as we have the separate system of drainage, our own and a company's electric mains often in duplicate, a company's water-mains, and our own gas mains, the streets are in a constant state of eruption. I find that when once taken up the soft wood blocks will not stand relaying, and though the initial cost is less, the cost of repairs is excessively heavy, as compared with the hard wood blocks.

Mr. J. S. PICKERING: I should like to ask Mr. Read to give us a little more information with respect to the installation of mechanical filters he has put down. I do not know whether there is any discrepancy in the figures, but I cannot agree with Mr. Read in his remarks that the expense of 5000*l.* is only about a quarter of the cost which would be entailed in putting down ordinary gravitating filters. For 20,000*l.*, roughly speaking, about 10,000 yards of filter beds could be put down which would filter 5,000,000 gallons a day. The water supply of Gloucester is about 1¼ million gallons a day. Perhaps Mr. Read will explain why 50 feet of head would be absorbed by an ordinary sand filter against 2 lb. loss of pressure in the Bell filters? Mr. Read does not give us any information as to the cost of mechanical filtration. It would be interesting to have the cost per thousand gallons of water filtered. It is very unusual in this county to adopt mechanical filters, and if it can be shown that they are efficient as well as economical, we should like to know more about them. I should like to know whether these mechanical filters are used the whole of the year, and the cost during the winter months when the water would not be so contaminated, and probably would require less filtration. Mr. Read says it is useful to add sulphate of alumina to the water. I should like to ask whether he actually uses this chemical, and if so, during what months of the year and in what quantities.

Mr. A. J. DICKINSON: There is one thing in Mr. Read's paper that always appeals to me, that is the reference to the intercepting trap. It is my pet aversion. I think the Local Government Board had some justification for putting it in the model by-laws in 1877, because in those days, and even in the present day, there are many rubble sewers which are practically elongated cesspools, and in such cases the intercepting trap is required to cut the drain off from the sewer. But where you have a properly laid self-cleansing sewer, and no sewer-gas can be formed, to put an intercepting trap on to the drain is a mistake, as it impedes the flow of the sewage. I have had some thousands put in during the last ten years, and I should be very glad if in the next ten years I could take them all out. I don't think an inspection chamber is sufficient. In Sheffield we always got a manhole provided. We put in the Windsor trap, with the raking arm, and I have seen the solid excreta coming up to the manhole cover. The intercepting trap is only a makeshift. The remedy is to get a properly laid sewer with self-cleansing gradients.

Mr. T. W. A. **Hayward**: I should like to join with Mr. Cotterell in expressing thanks for the historical part of the paper. I think it is most interesting for us to have these particulars given in the paper. If I might be allowed I should also like to say that we, as an Association, are indebted to the technical press for furnishing us with such interesting particulars of the places we visit. I think Mr. Read is to be congratulated on spending 2000*l.* on the installation of Deacon water meters, and as a result practically getting his water supply doubled, because it has reduced the consumption from 32 gallons to 16 gallons per head per day. That is a very cheap and effective method of increasing the supply, and one which might with advantage be copied in some other places. I have had some experience of the Deacon water meter, and can testify to the good results obtained when it is properly worked. I was particularly struck by what has been done in Gloucester in reference to the redrainage of the 3000 houses, which were formerly connected with the old culverts. If, as Mr. Scorgie mentioned, the cost of redraining the 2000 houses by the private owners was 10*l.* each, on that basis the expense to the Corporation of dealing with the remaining 1000 connections, would be 10,000*l.* The fact that there was an immediate drop in the death rate of three per thousand is very striking, and shows that the 10,000*l.* was money well spent. I quite appreciate the interest Mr. Read takes in the question of the intercepting trap. My friend, Mr. Cotterell, called my attention to it some fifteen or sixteen years ago, when he asked my opinion of the trap, at that time I thought it would be a retrograde step to abolish intercepting traps. When we consider the merits and demerits of the interceptor, we should know something of the state of the sewers to which the drains are connected. If the sewerage system is inefficient, I agree that intercepting traps should be retained, but with a system of sewers properly constructed with a flow of sewage which permits no decomposition in the sewers, then the weight of my opinion is against the use of an interceptor. One should look upon this question from the broad point of view, and decide according to the circumstances of the particular case under consideration. I think Mr. Read has looked after the sewerage question in Gloucester very thoroughly, an opinion which is confirmed by the low death rate of the city. I should like to ask for some further particulars as to the free tickets for the baths, which Mr. Scorgie was so interested in. I don't know whether Mr. Scorgie recommends the distribution of free tickets to charitable institutions and places of worship, but I do consider it extraordinary that such good results can be obtained from a 1½*d.* rate. In Battersea my Council hold strong views on this question. I went the other day with a friend—a well-known social reformer—into one of our baths, and at the time of our visit there were about 250 men swimming. An adjoining bath will easily accommodate between 200 and 300 women. My friend was strong in his opinion that adequate bathing facilities were necessary for the populace's moral well-being. I notice Mr. Bache says that during a certain test 1½ lb. to 2 lb. of water per pound of refuse burnt was obtained. I should like to know what the average results have been. It is not a difficult matter to get at the time of testing very good results which, after the test is over, the men who have to manipulate the furnaces fail to maintain. I must say the refuse and clinker I saw this afternoon did not impress me very favourably. The clinker had been taken out of the furnace too soon, and was not burnt as thoroughly as desirable. The primary function of a destructor is to destroy every particle that is capable of being destroyed, to burn refuse so as to get as much steam as possible is bad in practice and theory. I think the Gloucester city Council, and the city engineer in particular, have to be congratulated upon the stride they have made in the matter of refuse collection. To collect it three times a week in a place like Gloucester is very good indeed. I agree as to the objectionable method of placing refuse receptacles outside the houses. There are difficulties in the way of adopting a general system of night collection. I am sure the latter system would not do at Battersea. If the receptacles were placed out at night they would have gone before morning, and the refuse strewn about the streets. In some cases I make a daily collection, and in other parts of the district the refuse is collected two or three times a week, but when one has to deal with 150 or 200 tons a day, it is a difficult problem. I have tried to get residents to use the galvanised dust-bins, and to some extent have been successful. An endeavour should be made to impress upon the residents of towns that it is to their interests as ratepayers, as well as individual householders, to help the municipal officials in the collection of refuse.

Mr. G. **Bell**: The particular thing I should like to know at the present time is the cost of destroying the refuse—the total cost, if it could be got at. One would like to see how much is debited for interest and sinking fund, for all labour, including foremen's wages, repairs, and indeed, every item connected with the disposal of the refuse. But that, apparently, cannot be obtained in Gloucester, because it is mixed up with the electric lighting undertaking and cannot be given separately. I should like to say with regard to the removal of house-refuse I do not agree with the removal at night. It would be very objectionable in many ways. I have observed how the refuse is put out at Edinburgh, where the receptacles are kicked over, by the students principally, and the paper is set fire to in the streets. It has been suggested in Swansea that we should have collections at night. I have objected to it in committee as affording opportunities for those inclined for mischief, and have also pointed out the difficulties with respect to lock-up shops and offices. So far as we are concerned we have different times of collection. Some of the houses have a daily collection, some two or three times a week, and in the better class house they go as long as a week or a fortnight. Where you have got a good sized ashpit, and it is removed from the house, we find that no nuisance is caused. It is impossible to get round oftener than the times named to 18,000 or 20,000 houses with the limited staff we keep for the work. With regard to the intercepting trap, it does not appear to be quite clear whether Mr. Read has the courage of his opinions to leave it out altogether or not.

Mr. C. F. **Gettings**: Like the President, I noticed the flushing arrangement at the hotel. I should like to know if an unlimited flush is adopted all over the town, or whether a two or three gallon flush is generally adopted. If the flush is unlimited I should like to ask Mr. Read whether he considers this the most economical. With regard to the collection of refuse, I am sure there will be some very strong objections to any collection being made at night in a seaside and residential town such as I represent. Many residents in the suburbs lock their gates at night, and there are a number of lock-up shops in the town, so that special arrangements would have to be made in either case. Referring to the destructor, as one interested in considering the question of putting down an installation at the present time, and seeing that we have Mr. Read and the electrical engineer present, I should like to ask them whether they would consider it advisable for the local authority to put a plant down themselves and work it independently, or, if the company would undertake to put down a plant, whether they think it would be advisable to have a fixed charge for disposing of the refuse, or a scale of charges at per ton delivered at the works.

Mr. Read, in reply, said: I beg to thank you for the very interesting discussion raised on the paper. The President and several others referred to the Deacon meter system for detecting waste of water. To my mind it does not matter what amount of water you give people, they will ask for more and waste it, unless you exercise some control over them. The Deacon meter system gives you almost absolute control—just as much control as if you had a meter on every house service in the town. Some years ago I caused a meter to be fixed at a court with ten houses, where the residents drew their water from two taps in the yard, and the result of a twelve months' trial was that they used an average of 43 gallons per head per diem—and they were not particularly clean people either. I, also, about the same time put a meter on a new cottage where there lived a man, his wife, and four children, who did not know they were being supplied by meter—they did their own washing at home and were very clean people—and the result of the investigation was that their average consumption of water per day was 7 gallons per head. The Deacon meter system has this advantage, that you only trouble those people who waste the water, you have not to go to houses where there is no waste. The night inspector reports there was a waste at a certain house, and the day inspector searches until he discovers the leak or the cause of the waste of water at that house on the previous night. In that way you can keep the waste of water within very narrow limits. At the present time, the consumption of water does not exceed 22 gallons per head per day in this city, notwitstanding the fact that a constant service is given and that the water is used for the flushing of the w.c.'s, and almost every house without exception in the city has a flushing-box, which allows a 3-gallon flush. The water supply to the hotels is by meter. They are not restricted to a 3-gallon or any other flush, because they have to pay by meter. In regard to the collection of house-refuse, Mr. Harpur asked for an explanation of the difficulty about the boxes. Some people were in the habit of storing their refuse to the day nearest to the end of the week, and in order to do that they provided a box larger than the men can properly lift into the cart, and we have had one or two men ruptured. The remedy for that is to have the big boxes emptied by the ashmen into the road and the refuse shovelled into the carts, but that procedure causes delay which is undesirable. Then any sort of box is considered fit for refuse—old orange and starch boxes—and they soon get knocked to pieces. Then they are also overhauled by dogs and by people who are searching for valuables. The proposed remedy of putting the refuse out at night is, I fear, worse than the disease. We have great difficulty now in preventing boys upsetting the boxes which are placed in the streets in the morning, and I fear the difficulty would be much worse by night. With regard to the house connections made with the new sewers, it took me from 1878 to 1885 to get those 2000 houses connected to the sewers. It was very hard work, and it had to be done by persuasion. It was only by eloquence, persuasion, and constant worrying that it was possible to get as much done as we did. The 1000 owners, who stood out and did nothing, got it done at the cost of the town. When the work was done it was a very great advantage to the city as a whole from the health point of view. I believe under the Public Health Act, we were really liable to do the whole of the work. Then as to the free tickets for the baths. The numbers given are the total number of tickets issued in the year for all the baths. The free tickets are given away to the elementary school children, and they are distributed by the teachers. With regard to the Newent waterworks, that scheme was adopted after investigating some ten schemes mostly in the neighbourhood of Witcombe. We naturally started with the idea of keeping the works in the neighbourhood of the original Witcombe works, but none of the schemes were sufficiently reliable, and we went westward. An attempt had been made to find coal near Newent, where the landowners sank a shaft and got 1½ million gallons of water a day, and two or three loads of coal. This determined us to fix upon Newent for our supplementary work. We sank a bore-hole between two faults running north and south. The eastern fault had the marl on the surface on the east side of it, the new red sandstone was on the surface between the two faults, and the western fault had the old red sandstone on the surface on the west. The borings are 1200 feet deep, placed midway between the faults, and the water comes chiefly from the conglomerate beds which are shown in the section. The boring went through the Keuper beds of the new red sandstone, but did not entirely pierce the Bunter beds. The headings were driven along a thick bed of conglomerate, one to the west and one to the north. The headings cost about 5*l*. per foot. Mr. Scorgie asks why we use Chepstow stone for private street works and for making new streets. We use it because it reduces the first cost of making up streets. To my mind, for the first coating of a road you can do with a cheaper stone than you use afterwards in repairing the road. It gives the road time to consolidate. As these roads are not main roads, where the traffic is great, I think the procedure is the correct one from all points of view. The tunnel at Witcombe proposed by Mr. Bateman was the first proposal for enlarging the water supply, and the result of the borings which I made along the line of the proposed tunnel was not satisfactory. The Mitford sands at the base of the inferior oolite, which Mr. Bateman wanted to tap, proved so thin that although there was water in them, it would not have paid for making the tunnel. We thought it rather too risky a scheme to start upon. There were legal objections as well. We were trying to bring water flowing towards the Thames watershed back into the Severn watershed, and for that reason the Local Government Board would not have sanctioned the scheme. Mr. Cotterill has mentioned that Mr. Haynes at Newport is using sulphate of copper to kill weeds in the reservoir. I saw in the *American Engineer* that it was being used in America for killing weeds. I consulted our city analyst on the point, and he was of opinion that it would be a very risky thing to entrust to an ordinary workman, as he might kill off all the fish and give an overdose of copper, which would not be desirable to the inhabitants of the city. I understand it has been used in America, but we have to take American statements with several grains of salt. The intercepting trap I have always objected to. I think it is wrong in principle and does not do what is claimed for it. The idea with which it was invented and with which it was adopted by the Local Government Board in their model by-laws was that it cut off the sewer gas from the house. It can do nothing of the kind. On the contrary, it simply provides an obstruction which paralyses the whole action of the drain, and sets up a septic action in the sewage which has to go through it to the sewer, and the unfortunate borough engineer has to hunt a ghost in the form of a smell, the cause of which he cannot remove. Whatever the gradient of the drain, the sewage dribbles in at one end of the trap and out at the other, and leaves the solids and paper behind. With reference to the contention that the intercepting trap prevents sewer gas entering a house, how can the gas get into a house unless the drain is defective? and, if the drain is defective how can the presence of an intercepting trap cure it? There is sufficient gas in the drain itself to poison the whole of the people in the house. If the drain is sound, it doesn't matter what you put in it: you may put a fan in it and blow sewer gas through it, but it will not go into the house. If the drain is unsound, the intercepting trap will not and cannot protect the house in any way. You may have any number of definitions of what is a drain and what is a sewer, but drains and sewers are all parts of one system, which are mutually dependent on one another, and cannot be separated by any legal definition whatever. A question has been raised as to the cost per head of the infectious hospital. We bought a large amount of land, about 30 acres, and the hospital was designed by two local architects. The foundations and the levelling of the ground were very expensive. Those two points—the land and the foundations—are the causes of the excessive cost per bed.

Mr. Bache, in reply, said: All the speakers to-day have dealt with the refuse destructor except Mr. Scorgie, who asked some questions about street lighting. I had a discussion with him this morning on that matter. I think Mr. Scorgie is attacking the problem from the wrong end. He asks if there would have been as many arc lamps installed if the electricity works had been in the hands of a company. My reply is that no undue favour was shown to the electricity department. The question of installing arc lamps was discussed by the committee for many months, and very full and careful inquiries were made before it was finally decided to place the work in the hands of the electricity committee. Mr. Scorgie asks for the rate per unit for public and private lighting. The price charged for the arc lamps is based on a rate of 1½*d.* per unit. This covers not only works costs but interest on capital and depreciation of the plant required at the works for the arc-lighting. The average price received for private lighting is 3·6*d.* per unit. Mr. Scorgie also asks if the 5-ampere lamps are not too small. I do not think they are. They are only used for outlying districts, and, placed at a distance of 70 yards apart, they give a very good light for those districts. The height of the arc is 18 feet, which is the same as the height of the 7-ampere and 10-ampere arcs. As to the satisfactory burning of these 5-ampere lamps, they leave nothing to be desired. Had Mr. Scorgie asked the same question two years ago, I do not think I could have given the same answer. Mr. Scorgie argues that a good light cannot be necessary for the safe conduct of tramway traffic, otherwise it would be impossible to run cars outside the city where there is no lighting of any kind. It may not be absolutely necessary to light the roads well, but it is certainly advisable where there is fast and heavy traffic, to provide adequate illumination, and if the rural authority do not fulfil their duty in that respect, that is no reason why the city should not carry out what they consider a suitable scheme of lighting within their own boundary. I cannot give the total cost of destroying the refuse, as many of the items do not come under my department, but I may say that, in addition to the cost of the labour for burning the refuse, the electricity committee make a small weekly charge for supervision. This charge varies, but is about 1*l.* weekly. Mr. Hayward asked for the evaporation, other than on tests. We obtain 0·8 to 1 lb. of water per lb. of refuse. The quality of the clinker is not as high as in some towns, but we have to deal with a large proportion of paper, green stuff and other material of low calorific value, and this tends to prevent the formation of a good clinker. Mr. Read finds the quality quite good enough for his purpose, and therefore we leave well alone.

Before the discussion the President and Members proceeded in special cars to the Works of the Gloucester Railway Carriage and Wagon Company. On arrival they were received by Mr. R. Vassar Smith, Chairman, Mr. J. W. Howard, General Manager, Mr. A. E. Allen, Chief Assistant, and other members of the staff, and were conducted over the extensive Works of the Company, all the departments being thrown open for inspection. Visits were also made to the Corporation depot in Stroud Road, the Light Railway Car Depot in Bristol Road, the Electric Light and Power Generating station, and the Heenan and Froude Twin Cell dust destructor.

The Mayor entertained the President and Members to tea at the Guildhall.

The Members dined together at the Bell Hotel.

ANNUAL MEETING IN NORWICH.

June 22, 23 and 24, 1905.

THE PRESIDENT'S ADDRESS.

BY A. E. COLLINS, M. INST. C.E.

GENTLEMEN,—I am greatly gratified that the ancient City of Norwich, which I serve, has been honoured by your choice of place for the Annual Meeting, and I feel extremely proud at my election as your President. My own connection with municipal engineering is co-equal with the life of this Association. In my third of a century of service, I have seen great changes in public work. The growing town in which I served my articles had a population of some 60,000, yet the professional work of the borough engineer's office was done by the borough engineer and three pupils, there being no paid assistants. Probably this is representative of the small volume of work passing through most municipal offices in those days—quiet days never likely to recur for municipal engineers. Since that time constant additions to the statutes we have to administer, the gradual abolition of the contractor, and the continuously growing demands by the public for greater convenience, healthiness, and beauty in connection with all public works, have enormously increased our duties, and to-day their volume and variety are so great that a growing town of 60,000 inhabitants, to ensure the proper prosecution of its public works, must provide its engineer with a considerable and varied expert staff. Our work is of such a wearing, anxious, and absorbing character, that, more than any class of officers, we should be relieved by the public we serve from as much anxiety as possible, and it is for the public advantage at least as much as our own that such should be the case. Borough and county engineers, and engineers holding similar appointments under local authorities generally, whom I will hereafter describe under the collective term "municipal engineers," are more liable to earn dislike in properly carrying out their duties than any other officers of such authorities, and cases often occur where antagonisms created by the performance of duty have caused the driving from office of some of the best members of our profession. A man whose position is endangered by enmities caused by the proper performance of work and duties is not so free to serve the public properly as if he were efficiently protected. The absorption and anxiety attached to our work, and the inadequate salaries usually paid, prevent us from making such provision for the future, as men relatively as successful in ordinary walks of life as we are in our own can do. I doubt whether any other profession or business exists where the amount of study and work of preparation and constant daily anxiety are so great relatively to incomes earned as in our own. I do not remember a single case of one of our profession accumulating an ample competence from its practice. The greatest of prizes in it are small compared with those of other employments demanding anything approaching the same continuous, anxious, and responsible labour.

The Local Government Board, the central authority to which so much of our work is subject, have not given the position of municipal engineers the consideration it requires and deserves. It appears, in fact, that we are purposely placed in an unfair position by the Board whenever it is possible to do so. For instance, the consents of the Board to local authorities to raise loans for works designed and carried out by municipal engineers have been given conditionally upon these engineers receiving no payment from the loans; but at the same time payments have been authorised to clerks to local authorities, whose work relative to the matters in question is not a tithe of that of the engineer's. Further, it is not prohibited to make payments from loans to engineers in private practice.

Municipal engineering is a living, growing profession, having to do consequently with ever-changing practice. For a municipal engineer to keep pace with his profession, and to give the best service to his authority, he must constantly inspect and study the newest developments, and our Association arranges visits of inspection to municipal works of all sorts to aid its Members in this; yet the Local Government Board requires its auditors to surcharge payments by local authorities of expenses to our Members in attending our meetings. This action of the Board, more than anything else within my knowledge, shows the necessity for it to make the most careful and searching survey of its position relatively to municipal engineers. It is necessary to local authorities for their engineers to have the fullest knowledge of the progress of municipal engineering; at the same time it is unfair and unjust for their engineers, mostly an underpaid class, to be out of pocket in obtaining such knowledge for the benefit of their authorities. Again, the Local Government Board, when appointing inspecting engineers, whose chief duties are to hold inquiries and report on work done by municipal engineers, should endeavour to fill vacancies from the ranks of the municipal engineers; it is rarely, however, that such is done. I believe it would be to the advantage of the public generally if municipal engineers of ability and experience were appointed to such positions, and if they could look forward to occupying such positions as the reward of good service. The Local Government Board could greatly help local authorities, the public, and municipal engineers by obtaining authority from Parliament for and requiring that none of our appointments be held by other than competent, properly paid men, and by protecting such men when appointed from improper dismissal. Further, the Local Government Board should itself promote legislation ensuring superannuation to engineers, town clerks, and other officials of local authorities now omitted from superannuation schemes. This is already the case with Poor Law and Asylum officers and the police.

The Association of Municipal and County Engineers have done great preparatory work toward enabling the Local Government Board to insist on none but competent persons being appointed as municipal engineers. During the whole of its existence the collection and dissemination of knowledge necessary to the efficient performance of duty has been almost its sole aim, and in consequence the professional capacity of municipal engineers has vastly increased. Even I am able to remember the case of a man who was borough surveyor of a town of over 100,000 inhabitants who did not know how a sewer manhole should be built, and had to send outside his own office for a design. To-day any one of us is expected to design and carry out work of the most intricate and complicated character, and in the great majority of cases we do it, and do it well. Again, as assisting local authorities in connection with municipal engineering appointments, the Association has for many years conducted examinations to ascertain the suitability of candidates for such appointments, and, before permitting a candidate to sit at an examination, it makes full inquiries to insure that his education, training, and experience are such as will be likely to fit him for his profession. The preliminary investigations and the examinations themselves are so carefully and thoroughly performed, that the risk of an unqualified man receiving our certificate is reduced to a minimum. Without going further into detail as to tho manner in which the Association has done its utmost to enable it to be known who are competent, I think I have said enough to show that we have done our part in paving the way for the Local Government Board to assist public authorities and ourselves in appointing and retaining efficient engineers. To obtain the advantages which we are entitled and justified in expecting, each individual of us must use his influence wherever and in whatever direction he can exercise it. We must educate the members of the authorities we serve, the public, and last, but not least, members of the Legislature with whom we come into contact, with respect to the benefits to the public and the fairness and justice to municipal engineers and the officials of local authorities arising from granting what is asked.

One of the most important matters for our discussion at this meeting is that of New Streets and Buildings By-Laws, a subject which has for a long period been under the very serious attention of your Council, aided by the able and painstaking sub-committee appointed to consider and report thereon. Whilst I will not anticipate the paper and discussion on this subject, I desire to express the hope that as the result thereof we may greatly help toward showing how pleasant, comfortable, sanitary, safe, and durable houses may be erected at less cost than is possible under the by-laws now generally in force. I will only add, in this matter, that excessive fear of fire is, in my opinion, responsible for some of the present troubles.

In concluding, I desire to express the hope that this meeting in Norwich will be remembered hereafter as a most valuable and enjoyable one, and that during my year of office I may be able to help in the progress of our Association.

SUGGESTED AMENDMENTS TO THE MODEL BUILDING BY-LAWS FOR NEW STREETS AND BUILDINGS.

By ALBERT D. GREATOREX, Assoc. M. Inst. C.E., Borough Engineer and Surveyor, West Bromwich.

At the request of the President, and in order to give the Members an opportunity of discussing some of the suggested Amendments to the Local Government Board's Model Code of Building By-laws, the Author has prepared the following few notes, in the hope of eliciting an expression of opinion on the subject generally, and thus obtaining the views of the Members of this Association, who, after all, are the officers upon whom devolves the duty of carrying out the Acts of Parliament and By-laws made under the provisions contained therein, relating to New Streets and Buildings in most of the non-metropolitan districts.

For the past eighteen months a Special Committee appointed by the Council has been considering this important subject. As a result of their labours a report was submitted, together with certain amendments and suggestions, to the Local Government Board's Code. This report was considered and approved at a Special Meeting of the Council, and has been submitted to the Board, who are giving the subject their attention, and it is to be hoped that the labours of the Committee will not have been in vain.

The Author having carried out the duties of Hon. Secretary, it naturally follows that many of the suggestions contained in this paper are the opinions of the Committee, and in placing them before the Members he does so with the sanction of his colleagues.

At the First Annual Meeting of this Association, held in Birmingham in May 1874, under the Presidency of our esteemed Past President, Mr. Lewis Angell, M.Inst.C.E., a paper was read by Mr. J. Lemon, M.Inst.C.E., the then Borough Surveyor of Southampton, entitled: "Building and Sanitary By-laws" (see vol. i. p. 39, 'Minutes of Proceedings').

In the discussion following this paper it was suggested that the by-laws should be swept away and a universal Building Act adopted. In the opinion of many this would be the proper course to pursue to-day.

The following papers have also been contributed on this subject:—

Paper by Mr. E. B. Ellice-Clark, M.Inst.C.E., entitled: "The Supervision of Private Building by Public Authority," read at a District Meeting held at Brighton, March 15, 1884 (see vol. x. p. 83, 'Minutes of Proceedings').

Paper by Mr. F. C. Cook, Surveyor to the Urban District Council of Hinckley, entitled: "The Position of Local Authorities in regard to Building By-laws," read at a District meeting held at Birmingham, April 5, 1902 (see vol. xxviii. p. 141, 'Minutes of Proceedings').

At this meeting the following resolution was unanimously adopted, namely: "That the Council of the Association be requested to take into consideration the existing unsatisfactory condition with respect to the making and administration of By-laws relating to New Streets and Buildings, with a view to representation being made to the Local Government Board thereon."

This resolution was the forerunner of the Special Committee already referred to.

At the Sanitary Institute Congress in Birmingham in September 1898, Mr. J. S. Pickering, A.M.Inst.C.E., read a paper entitled "By-laws relating to New Streets and Buildings" (see vol. xx. p. 67, 'Journal of the Sanitary Institute'), and Mr. H. D. Searles-Wood, F.R.I.B.A., read a paper at a meeting of the Sanitary Institute, held March 22, 1905, entitled "Notes on Minimum Sanitary Requirements for Building By-laws."

Two papers have recently been read at the Surveyors' Institution, and in the discussion that followed, several speakers made suggestions that there should be uniform by-laws throughout the country, and a tribunal of appeal.

Mr. A. Macmorran, K.C., suggested:—

1. That the whole code of by-laws ought to be revised by experts.

2. That the power of making by-laws should be restricted to matters specially affecting localities.

3. That in so far as there was discretion to dispense with by-laws that might be applicable to local authorities, that discretion should be the subject of appeal to a competent and expert tribunal.

Mr. R. M. Chart, in the same discussion, gave the six points that could, in his opinion, be dealt with in the public statute as follows:—

1. The laying out, and making and draining of new streets.
2. The sufficiency of space about buildings to secure a free circulation of air.
3. The provision of foundations and damp course, and the concreting of sites, and eaves and gutters necessary to secure the premises against damp.
4. Provision for proper sanitary conveniences and drainage.
5. Provision for sufficient windows, and their being made to open.
6. A minimum height of living and sleeping rooms.

And suggested that special by-laws should be made with regard to other matters applicable to urban districts, consisting of a specified density of population.

Mr. William Henman, F.R.I.B.A., of Birmingham, in a series of articles in the 'British Architect,' suggests that the by-laws should be drawn so as to provide that certain things, well ascertained to be detrimental to safety or health, shall not be done, and said; that the principle on which building by-laws have been drawn up is wrong, because they generally dictate what is to be done before actual requirements have been ascertained; and suggested that the proper principle would be, first, to decide what, in matters connected with buildings, is proved to be detrimental to safety and health, and then to define what shall not be done.

The Council of the Royal Institute of British Architects appointed, in 1899, a Special Committee to report on building by-laws in non-metropolitan districts. This report was duly submitted by the Committee and recommended by the Council to a meeting of the Institute held June 12, 1899, and adopted. (See 'Journal of the Royal Institute of British Architects,' vol. vi. 3rd series, No. 15, p. 449.)

In this report the Committee state that the by-laws of many districts vary in several particulars from the model by-laws, and from one another; this want of uniformity in districts closely adjacent causes inconvenience and irritation to building proprietors as well as to architects. The report also states that the enforcements of unnecessary regulations in respect of matters in which the public has no practical interest, seems to the Committee an improper interference with the liberty of the subject.

It gives useless trouble to local authorities.

It multiplies, undesirably, officials to be paid out of the rates.

It adds unreasonably to the cost of building.

It promotes monotony in design, stultifies invention, and prevents improvement. It occasionally stops building; more particularly it discourages the erection of cottages for the labouring classes by landed proprietors on their country estates.

The committee recognised the necessity of such building by-laws as are proved to be essential to the safety of the health of the public, and desire that the by-laws relating to the same subject should, as far as practicable, be alike throughout the country; they suggested that the model by-laws should be grouped in divisions as detailed in the report, in order that buildings in rural localities may be relieved from those divisions which appear inapplicable in such places, and, in an appendix they give the amendments which appeared to them needed therein.

The divisions they suggested are as follows:—

A. Definition of terms, and exempted buildings (model by-laws 1 and 2).

B. New streets (3–8).

C. Space about buildings and area of windows (53–58).

D. Structure of party walls (25–32).

E. Structure of walls, foundations, roofs, and chimneys (11–23, 33, 34, 36–52).

F. Sanitation, preparation of site and drainage (9, 10, 17, 52A, 60–89).

In rural districts the committee considered that *A*, *D*, and *F* would suffice. It might be desirable to add *B*, in the case of any part of a rural district likely to become urban, possibly *E* might be added, to apply only to large public buildings, warehouses, and factories of considerable height; ordinary shops should not be regarded as other than domestic buildings.

In towns where a competent building surveyor of experience is engaged, the committee considered that the whole of the by-laws should be in force. In such places, exemptions from certain divisions of the by-laws should be made applicable to particular buildings, rather than to districts, and the committee were of opinion that in no case should the exemptions extend to sanitary matters.

As regards the deposit of plans, this committee suggest a block plan only showing the drainage, etc., and that, where required, plans and sections together with elevations, if needful to explain methods of construction, should be submitted for inspection during a defined and limited time, which drawings should be returned stamped, if approved, or, if not approved, accompanied by a precise statement of the particulars in which the by-laws have not been complied with.

The committee also stated that it would, in their opinion, be a great advantage if an appeal could be provided to a technical authority as to the meaning and applicability of by-laws.

With many of these opinions the Author is prepared to agree, and considers the Institution has approached this question in a very fair and reasonable manner.

The Council of the Incorporated Society of Medical Officers of Health have also had this subject under consideration, and have prepared their amendments and suggestions to the Model Code of Building By-laws for Rural Districts; but as their report has not yet been adopted by the Society, the Author is not in a position to quote from the same.

The Building By-laws Reform Association, instituted December 8, 1902, have introduced a Bill (see Appendix A) into the House of Lords to amend the Public Health Acts, which Bill has been read a second time and referred to a Committee.

The objects of the Bill are stated as follows:—

1. To exempt buildings sufficiently isolated from the operation of existing and future building by-laws.

2. To provide against alterations of buildings erected under the exemptions provided by the above.

3. To render exempted buildings subject to by-laws relating to sanitation.

4. To empower the Local Government Board upon representation by ratepayers, to disallow by-laws after confirmation where any such are found unsuited to the district in respect

to which they apply, or to operate contrary to the public interests.

In a Memorandum issued by that Association they state that the proposed Bill has been prepared by them in the hope that it will remove some of the principal difficulties and causes of friction in the administration of building by-laws without impairing their efficiency. It is designed to facilitate the erection of cottages and small houses, especially in country towns and rural districts where the want of accommodation for workmen and labourers is acknowledged to be acutely felt, and at the same time to free other houses with plenty of land around them from the unnecessary restrictions imposed by existing building by-laws.

They state that the building of cottages is now discouraged by three things:—

1. The expense of building to comply with by-laws as to structure.

2. The fear of friction and expense arising out of the administration of by-laws.

3. The unsuitability of by-laws to the needs of the districts in which they are in force.

They also state that the Bill, if passed, would remove these difficulties:—

1. By exempting (clause 2) from the operation of by-laws as to structure, houses and cottages where sufficient open space is provided all round them for the purposes of health and amenity, and preventing the spread of fire.

2. By giving (clause 5) the Local Government Board power upon complaint to recall any by-laws which may be unsuitable to the district in which they are in force.

The Bill expressly provides (clause 4) that it shall not operate to exempt any building from by-laws relating to sanitation, and it contains provisions (clause 3) to prevent building contrary to its requirements.

The principle of exemption in return for space is recognised in London by section 201 of the London Building Act, 1894, and there is no valid reason for refusing to extend it to the country.

The power to recall existing by-laws (clause 5) would conduce to their being more carefully administered, and would enable the Local Government Board to provide districts with good by-laws with a minimum of cost, delay, and friction.

The Bill applies to both urban and rural districts, and will, it is hoped, encourage the building of labourers' cottages with an adequate amount of garden ground attached to them, and at the same time relieve owners of property from interference, not only unnecessary, but often actually detrimental to the public interest.

In the opinion of the Author, this Bill will require very considerable amendment before it can be expected to receive much support, although one may have the greatest sympathy with the promoters.

In considering this question the Committee had particularly in mind the following objects:—

1. To ascertain whether the existing by-laws can be modified so as to lessen the restrictions which are said to exist in such a way as not to affect the stability and safety of buildings, both in urban and rural districts, at the same time securing that the laws of public health may be adhered to.

2. Whether such modifications would make it possible to reduce the cost of the erection of buildings, more especially for the artisan class.

3. If any, and which, by-laws could be altered with advantage to the general public.

The question of the possibility of reducing the cost of erecting cottage property by modifying the by-laws requires very careful consideration as affecting owners, tenants, and the general public.

The consequence of such reduction would probably be on the one hand the erection of houses which could let at a less rent than is at present charged for houses of similar accommodation, and on the other hand a considerable modification of the by-laws might open the door for the erection of less substantial and unhealthy dwellings.

By-laws are framed chiefly for the purpose of securing conditions of health for the individual and the community, stability of property and security from fire, and in their consideration these objects should be kept constantly in view.

The by-law committee, after careful consideration, have come to the conclusion that modifications can be made without in any way endangering any of the above principles, and have offered (as already stated) to the Local Government Board many suggestions on these lines for their consideration.

The Author suggests various additions and amendments to the existing model building by-laws for both urban and rural districts* as follows:—

Interpretation of Terms.—Many of the larger towns and urban districts in their latest by-laws have provided for the definition of the following terms used in the by-laws, such as "surveyor," "foundation," "topmost storey," "lowest storey," "ground storey," "ground floor," and also definition of fire-resisting materials; these should be included in the Board's Model Code.

Owing to the erection of flats and composite buildings, a definition is needed to cover such; this is of course more particularly felt in large towns.

Exempted Buildings.—By-law 2, paragraphs H to L (inclusive).

Considerable expense and difficulty are now experienced, owing to the necessity under the by-laws of having to submit plans of such buildings as plant houses, aviaries, fowl houses, coal houses, and similar structures, and it is suggested that these buildings might be erected on permission being obtained from the sanitary authority, so long as the minimum area of open space required under the by-laws is not interfered with and the sanitary requirements are complied with, without the necessity of submitting plans, provided seven days' notice in writing is given to the local authority before the erection of such a building.

At the present time most by-laws require buildings to be of brick, stone, or other incombustible material.

In order to allow of buildings being constructed of other suitable materials than brick or stone, under certain conditions, a by-law providing for the external walls being constructed of suitable material of adequate strength to secure proper stability and constructed to be weather-proof should be included; this would to a very large degree remove, especially in rural districts, the present outcry against the cost of building, and would allow of half-timbered buildings, buildings of wood and corrugated iron, reinforced concrete, and other forms of construction.

The Author would here point out that other circumstances have materially added to the cost of buildings, such as the increased cost of materials and labour, and the restrictions as to hours and rules in various trades; rents of cottage property too are undoubtedly increased to meet the increased rates and taxes, both local and national.

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* Appendix B gives a synopsis of the Local Government Model By-laws referred to.

With respect to the Level, Width, and the Construction of New Streets.—In framing by-laws every district has adopted a certain minimum width, according to the individual views of those drafting or having the approval of the by-laws.

After careful consideration the committee adopted the following recommendation.

That the minimum width of streets for urban districts should be as follows:—

(*a*) 40 feet for side streets.

(*b*) 50 feet for more important streets.

(*c*) 60 feet for streets that are main lines of communication or in continuation with same.

In rural districts no street should be less in width than 36 feet, and all main lines of communication should be 25 feet from the centre of the road to the forecourt wall.

Narrow roads whether in urban or rural districts are a mistake, a great inconvenience, and a source of danger to the public, especially under the present conditions of traffic.

Enormous sums are constantly being paid to widen streets, and what is a country district to-day may very soon become part of a more populous area.

In country districts if the required distance were kept between the building lines, it would be possible to allow of forecourts being provided and the streets made narrower than suggested, so that they could be widened at any future date at small expense and so save expensive street construction in the meantime.

As regards the width of footways and carriageways and the specification for street construction, these should be left to the local authority to determine in the large districts, as is generally done at present in many towns under private Acts; and in small urban and rural districts the model code should be enlarged to provide for a more complete detail of the method of construction so as to leave no loophole of doubt as to what is required.

With respect to the Structure of Walls.—Very few by-laws provide for the interpretation of the following terms, and these should precede the clause dealing with building construction, namely:—"sand," "lime," "cement," "lime mortar," "cement mortar," "concrete," "plaster," "asphalt," and similar terms; these should be complete both as regards the quality of the material, composition, and other details.

By-law 14.—Provides for the erection of new buildings of brick, stone, or other hard and incombustible materials, properly bonded and solidly put together with cement, lime, or cement mortar, and provides for certain exceptions as hollow walls and half-timbered buildings.

Provision should be made for the thickness of material other than brick or stone under this by-law; the model code has no provision for walls constructed of iron or steel framing: this should be included, and also provision made for reinforced concrete, or other similar construction.

All iron or steel-framed buildings should be covered with, embedded, or encased in, concrete or other fire-resisting material.

By-law 21.—As regards thickness of cross walls.

This by-law has a very important bearing on the thickness of external and party walls, inasmuch as the existence of proper cross-walls of the required thickness determines the length and consequently the thickness of such external and party walls.

The Author suggests that this by-law be amended so as to provide that a pillar or buttress of a length of not less than one-tenth of the height of such wall, but in no case less than 3 feet in length, be allowed in substitution for the wall carried through from back to front.

By-law 22.—As to the thickness of walls of domestic buildings.

This and the following by-laws are very intricate ones, and they give more trouble in administration than all the rest.

The principal difficulty consists in having laid down hard and fast rules which cannot always be administered without the infliction of apparent hardship on the persons concerned.

The principle of the rules appears to be that walls of domestic buildings less than 25 feet high and 30 feet long must be 9 inches thick throughout, that if either the height or length is increased, the thickness of the walls must accordingly be increased as set forth.

As general rules the provisions of the by-laws do not appear to be unreasonable, but in practice the application to cottage property sometimes presents difficulties in respect to party and gable walls, both as regards height and length as fixing the thickness.

The difficulties experienced might be very much reduced if the by-law were amended so as to allow of domestic buildings being erected up to 30 feet in height and 30 feet in length with 9-inch walls; this would allow of three-storey buildings.

There is also the question whether some concession might not safely be made in respect to permitting the external walls of sculleries, wash-houses, closets, tool-houses, or ash-places, appurtenant to a domestic building, to be erected only 4½ inches thick instead of 9 inches as required by this by-law, provided these walls were built with cement mortar, and subject to certain restrictions, such as the size of such buildings, etc., and provided that the foundations and party walls were constructed of 9-inch brickwork.

This amendment would in the opinion of the Author be a concession of some value in the erection of cottage property.

By-law 23.—Here again this by-law should be amended so as to allow greater latitude as regards the height and thickness of walls for warehouse buildings, and a clause inserted dealing with external walls, which may be retaining walls.

A clause might also be inserted to provide that where a wall is constructed of cement concrete other than ferro-concrete, the thickness should be at least one-fourth greater than that required in the previous by-laws.

Construction of Chimneys.—A by-law should be provided to deal with the construction of chimneys, to include any suitable form of construction, such as the Alphons Custodis principle, steel or other suitable materials.

With respect to the sufficiency of space about buildings to secure a circulation of air, and with respect to ventilation of buildings.

By-law 53.—This by-law should be improved by the addition of the following proviso:—

"Provided that where a scullery not exceeding 10 feet 6 inches in height, measured from the floor of such scullery to half-way up the roof, is erected at the back of such dwelling-house, he may cause the distance across such open space between such scullery and the said boundary to be one-fifth less than the distance as prescribed, if thereby no diminution of the minimum aggregate extent of 150 square feet is involved. Provided also that any scullery to be so erected shall not be allowed to extend across the back of such building to an extent of more than three-fifths the width of any habitable room to which such scullery is attached, and provided, also, that such scullery shall leave sufficient light and ventilation for any habitable room."

By-law 56.—As regards this by-law "one-twelfth" should be substituted for "one-tenth" of the floor area for windows where the light is unobstructed, and the top of the window should be not less than 7 feet from the floor except for rooms in the roof, unless some additional means of ventilation be provided near the top of the room.

Also that provision should be made for ventilation of bath rooms, lavatories, and sculleries, with the exception that "one-fifteenth" should be substituted for "one-twelfth" in such cases. Pantries under staircases should also have proper means of ventilation provided.

Opening skylights for rooms partly or wholly in the roof should be regarded as windows.

With respect to the Drainage of Buildings.—In front of the by-law under this heading there should be inserted an interpretation of the following words, namely, "stoneware pipes" (this should be accompanied by a schedule for sizes, etc.), "soil pipes," "ventilating pipes," and other materials; the weight and method of jointing soil pipes and ventilating pipes should also be given.

By-law 62. *Paragraph* 2.—This by-law should be amended so as to provide for drains being laid straight, both in line and gradient, and with joints watertight, and where practicable, with a fall of not less than 1 in 36; if the fall is less than 1 in 48, proper means for automatic flushing should be provided.

Paragraph 3.—Should be amended so that the joints of the pipe above the ground shall be of molten lead, and this paragraph should be altered so that the provision for piers should only be applied when the drain is above the ground.

Note.—By this by-law a new drain shall not be constructed so as to pass under any building unless the precautions contained in this, and the subsequent paragraphs, are observed; but where the drain is already in existence, or has been in existence more than six months, a person may erect a new building without observing any of these precautions, and the by-law to that extent requires amendment.

Paragraph 4.—Concrete not necessary in all cases; therefore add "where the nature of the ground requires it."

Paragraph 5.—The phrase "highest point" not satisfactory, the requirement should apply to the whole length of pipe, and the distance should be equal to the full diameter of the drain, and in no case be less than 6 inches.

By-law 63.—Add words to define means of access, say "by means of a manhole chamber, or vertical shaft, having a diameter of not less than that of the drain."

By-law 65.—Provision should be made for rust pocket at the bottom of the ventilating pipe.

By-law 66.—Provision should be made for anti-syphonage, and soil pipes should not be used as rain water pipes, nor rain water pipes for ventilation purposes.

With respect to water-closets, earth-closets, privies, ash-pits, cesspools, in connection with buildings.

By-law 67.—The word "earth-closet" should be left out, same as in rural by-laws, and the clause amended, so that water-closets shall not open directly into any room wholly or partly used for human habitation, or, as a place of habitual employment for any person in any manufacture, trade, or business.

By-law 68.—Windows are not necessary for outside water-closets wholly detached from the building; proper ventilation can be obtained by cutting the doors.

By-law 69.—The following words should be added after "adequate capacity," "capable of giving a flush of not less than two gallons." Committee suggest that a three-gallon flush should be provided for.

By-laws 70 to 91.—Dealing with ash-pits, privies, and cesspools, the rural model should be adopted instead of the urban; and as regards ash-pits, the committee suggest a by-law to provide for ash-bins, and recommend that permanent ash-pits be done away with.

There are many by-laws not provided for in the model code, although they are usually to be found in most urban codes, and it would be an advantage if they were included in the model, and many towns have, under private Acts, very useful by-laws which should not be lost sight of in framing a new Building Act.

As to giving of Notices, Deposit of Plans, etc.—As regards the deposit of plans of new buildings, and alterations to existing buildings, proper plans giving the different floors, sections, block plan showing drainage, etc., should be compulsory in all districts, and they should be deposited on tracing linen, or other suitable and durable material other than tracing paper.

In recent discussions on this subject, many speakers have suggested that no plan was necessary, especially in rural districts; this, in the opinion of the Author, would be a retrograde step. How would it be possible for a surveyor in a large rural district, with a limited staff, to see that the by-laws were being carried out? He would be at the mercy of the speculative or jerry builder, or liable to be called over the coals by his council for the erection of buildings which did not comply with the by-laws, owing to his lack of knowledge of the builder's intention until too late to interfere.

The Author does not believe for one moment that any well-meaning landowner, or respectable firm of architects or surveyors, have any *bonâ-fide* or real objection to the deposit of such plans as we suggested. Plans are far more necessary in rural districts than in some of the large cities and towns.

The only alternative to no plans is for the council to provide a large staff of assistants, who would constantly be perambulating the distrct in examining new buildings, to see that they comply with the by-laws, and would lead, in the opinion of the Author, to far more disputes and criticism than the present arrangement.

If plans are disapproved on being submitted to the authority, the Author quite agrees that the person depositing them should be informed in writing in what way they are wrong, or do not comply with the by-laws, and so avoid unnecessary friction and annoyance.

Considering the thousands, tens of thousands, or probably, more than hundreds of thousands of plans of buildings which pass through the hands of, and have to be supervised by, the officials of local authorities every year, the small amount of friction which arises is to be wondered at, considering the complex subjects to be dealt with; and it should not be assumed, from the comparatively few cases which come into court, that friction is continually taking place between those responsible for carrying out by-laws and those engaged in the erection of buildings; such is not the case.

In the discussions that have taken place of late, the point has been raised, what is a new building? If the following clause, granted in many private Acts, were adopted in a general Act or building code, much of the difficulty would be removed.

"From and after the passing of this Act—

"The erection of any building;

"The re-erection, wholly or partially, on the same site of any building, of which any outer wall is pulled down to or within 10 feet of the surface of the adjoining ground, and of any frame building so far pulled down as to leave only the framework of the ground floor storey thereof;

"The conversion into, or using as a dwelling house, of any building, or part of a building, not originally constructed for human habitation;

"The conversion into one dwelling house of two or more dwelling houses, constructed originally as one dwelling house;

"The conversion into, or using as two or more dwelling houses of any building constructed originally as one dwelling house;

"The conversion of a building which, when originally erected, was legally exempt from the operation of any building by-laws in force within the borough, into a building which, had it been originally erected in its converted form, would have been within the operation of those by-laws;

"The re-conversion into, or using as, a dwelling house of any building which has been discontinued as, or appropriated for any purpose other than, a dwelling house;

"The conversion into a dwelling room of any room, or part of a room, used as a shop;

"The making of any addition to an existing building by raising any part thereof, or making any projection therefrom, but so far as regards such addition only; and

"The roofing or covering over of an open space between walls or buildings;

shall for all the purposes of this part of this Act and of the Public Health Acts, and of any by-law made thereunder respectively, be deemed to be the erection of a 'new building.'"

A great deal has of late been said as regards the competency or otherwise of those responsible for administering the by-laws, whether they be the disinterested gentlemen who serve their less fortunate fellow ratepayers, or the much-abused officials.

As regards the former, the opinion has very freely been expressed that the members of local authorities are actuated by a desire to do their duty in the best manner according to their ability; it is a well known fact that applies to all districts, be they town or rural, that there is great difficulty in obtaining many of the best members of the community to come forward and give their services freely for the benefit of the many; possibly there is a lack of interest in the work, or apathy for the consideration of others; someone must, therefore, perform what possibly others are better able to carry out.

With reference to the latter, this is a matter after all which is entirely in the hands of the general public, if the Acts of Parliament and by-laws of the country are to be administered by competent men, and there cannot be two opinions as to the desirability of this.

All officials of local authorities should be appointed subject to the sanction of the Local Government Board, as in the case of Poor Law Officers; and security of tenure and superannuation, of which we have heard so much of late, should be given to all.

Whilst one regrets to hear that there are in some of the smaller districts incompetent officials, one does not have very far to look for the root of the evil: it lies in the miserably small salary offered for the duties of the office, a salary in many cases less than that paid by many of us to our foremen. The reason of this may be that the town cannot afford an adequate salary; if that is so, the Author suggests that larger districts should be formed, so that competent men may be engaged at a reasonable salary, and that they should devote their whole time to the duties of their office.

Districts might be grouped together for this purpose, as is done for sanitary purposes in many parts of the country.

The Author suggests that the present building by-laws should be remodelled, or a universal Building Act adopted, which should be compulsory, and power should be given to each district, subject to the sanction of the Local Government Board, to frame regulations as to the minimum size and strength of material to be used in the construction of buildings, drainage, and other particulars.

They should be concise, deal consecutively with the various subjects, follow the same order in which they usually have to be dealt with in building operations, be provided with a full index, marginal notes, explanatory illustrations, and diagrams.

In framing these regulations greater latitude should be given to each district, making them vary, according to the requirements of each particular district. They would not then be so cumbersome and unnecessarily lengthy.

At the same time definite rules should be laid down, as it would be dangerous to make them too elastic, or they would not be properly enforced.

It would no doubt be necessary, in order to provide for some of the by-laws as herein referred to both for urban and rural districts, for the Local Government Board to obtain further powers.

Power might also be given to charge fees for the supervision of all buildings on the same lines as is done in London under the Building Acts, and several other towns under private Acts.

In the recent discussions that have taken place it has been suggested that the Institute of British Architects and the Surveyors' Institution could frame such a Code of By-laws as would be acceptable to the Local Government Board, the architects, building owners, and the general public.

The Author is of opinion that in the event of experts being asked for further suggestions for the proposed Building Act or amended by-laws, the Members of this Association should be consulted in a matter in which they are so deeply interested, as no Association is more competent or better able to assist in this matter.

In conclusion, the Author has endeavoured to keep clear of the points covered by previous papers, and wishes to express his thanks to those who have so kindly lent him various pamphlets, journals of other Associations, reports, by-laws, etc., and, also to say how much he appreciates the valuable assistance rendered by his colleagues, both members of the Council and those co-opted in the work of the By-laws Committee. A great deal of time has been spent in considering the details of each by-law by that Committee, and whilst the Author has here only referred to the more important alterations, at the same time, there are many minor amendments and suggestions which can be brought forward when the matter is finally discussed, or a revision takes place; and he hopes that the suggestions here made may be productive of a good and useful discussion.

APPENDIX A.

A BILL INTITULED "AN ACT TO AMEND THE PUBLIC HEALTH ACTS."

WHEREAS it is expedient to amend the provisions of the Public Health Acts:

Be it therefore enacted by the King's Most Excellent Majesty by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:—

1.—(1) This Act shall be construed as one with the Public Health Acts, and shall extend to England and Wales, exclusive of the administrative County of London.

(2) This Act may be cited as the Public Health Acts (Amendment) Act, 1905, and this Act and the Public Health Acts may be cited together as the Public Health Acts.

2.—(1) The following buildings shall be exempt from the operation of any by-law now or hereafter in force within any "County District" with respect to the structure of walls, foundations, roofs, floors, chimneys, or hearths, or with respect to the sufficiency of the space to be provided about buildings, or with respect to the ventilation of buildings, or with respect to the giving of notices or the deposit of plans or sections, namely:—

> Any building, not being a public building or factory (or which, being a public building or factory, is one storey only in height and is without any gallery), which is situated at a distance from every boundary of the curtilage thereof of not less than fifteen feet, or if the height of the building measured from the ground base thereof to the spring of the roof exceeds fifteen feet, at a distance from every boundary of the curtilage thereof, at least equal to such height, and also at a distance from any other building of not less than thirty feet.

(2) A building shall not be excluded from this exemption by reason of its being situated within the distance prescribed by subsection 1 of a boundary of the curtilage thereof fronting or abutting on a street, provided that no part of such building is situated within such prescribed distance from the centre of such street.

(3) A detached dwelling-house shall not be excluded from this exemption by reason only of it, being within thirty feet of another detached building constructed as stabling or offices to be used in connection with such dwelling house.

(4) For the purposes of this Act two dwelling-houses separated

by a party division of fire-resisting material shall be deemed to be a single building.

3.—(1) If any addition be made to any such building specified in section 2 of this Act whereby any increase is caused in the height of such building, or any diminution in the distance thereof from the curtilage or from any other building, so that the same shall be of greater height or less distance than those respectively in such section mentioned, the district council may give notice to the owner or occupier of such building requiring the removal of such addition within a reasonable time to be named in such notice, and if default shall be made in complying with such notice the exemption provided by the said section shall thereupon cease to apply to such building.

(2) If any alteration shall be made to the curtilage of any building specified in section 2 of this Act, whereby such building shall be situate at a less distance from any boundary thereof than is in such section mentioned (regard being had to sub-section 2 of such section), the exemption provided by the said section shall thereupon cease to apply to such building.

(3) Upon the exemption provided by section 2 of this Act ceasing to apply to any building (by reason of sub-sections 1 or 2 of this section) such building shall for the purposes of any by-laws in force within the county district in which the same is situated, and of the enforcement thereof, be deemed to have been first erected by the then owner, thereof at the time of such exemption ceasing to exist in respect thereof.

4.—Nothing in this Act contained shall exempt any building from the operation of any by-law with respect to the drainage of buildings or with respect to water-closets, earth-closets, privies, ashpits, or cesspools in connection therewith.

5.—(1) Where any by-laws made under the provisions of the Public Health Acts are in force in any county district the Local Government Board shall, upon application signed by five ratepayers in this district, hold an inquiry as to the operation and effect of any such by-laws specified in such application, and may by order disallow any such by-laws either wholly or in part, and from and after the date provided in that behalf in any such order any by-laws disallowed thereby shall cease to have effect. The Local Government Board may by any such order of disallowance direct that any by-laws specified therein shall from and after a date to be named therein be substituted for the by-laws disallowed until such time as new by-laws shall be passed by the Council of such district and allowed by the Local Government Board, and such substituted by-laws shall have effect accordingly.

(2) The Local Government Board may at any stage require payment to them by such applicants of such sum not exceeding fifty pounds as they may deem right to provide in the first instance for any expenses of the Board in connection with any inquiry held under this section, and at or after any such inquiry the Board may make an order by whom the costs of the inquiry shall be borne, and may by such order direct that any sum paid to them as aforesaid shall be dealt with as they may deem right.

APPENDIX B.

SYNOPSIS OF MODEL BY-LAWS, AS ISSUED BY THE LOCAL GOVERNMENT BOARD, PROPOSED TO BE AMENDED.

BY-LAW No. 1.—*Interpretation of Terms.*—The following words are defined:—"District," "Council," "Base," "Party Wall," "External Wall," "Public Building," "Buildings of the Warehouse Class," "Domestic Building," "Dwelling House," "Bressummer," "Width," as applied to a new street.

BY-LAW No. 2.—*Exempted Buildings.*—Paragraphs H to L include any building erected for the purpose of a plant house or conservatory, poultry house, cycle shed, etc., which, if exceeding 600 cubic feet, shall be at least 10 feet away from any other building; any other buildings which shall not exceed certain limits, or be used as a public building, or for human habitation or employment, and erected within specified distances from any adjoining land or premises.

BY-LAW No. 4.—*With respect to the Level, Width and Construction of New Streets.*—Streets to be laid out with best practical gradient and easy means of communication with other streets.

(1) Any new street intended for use as a carriage-road to be 36 feet wide.

(2) Any new street exceeding 100 feet to be constructed as a carriage-road, provided it forms the principal approach to any building.

BY-LAW No. 6.—A new street intended to form a principal approach to any building, and intended for use otherwise than as a carriage-road, and which does not exceed 100 feet, shall be 24 feet wide at least.

BY-LAW No. 7.—A new street intended to be used as a secondary means of access to any premises for the removal of refuse, shall be 16 feet wide, or, if less than 100 yards in length, 13 feet wide.

By-law No. 8.—Any new street intended to form a principal approach to any building, shall comply with the following requirements:—

(*a*) The carriage-way to be 24 feet wide.

(*b*) Camber of carriage-way to be between ⅜ and ¾ of an inch per foot.

(*c*) Footway to have a cross-fall of ½ inch per foot if not paved, and half this if paved.

(*d*) Channel to be not less than 3 inches, and not more than 7 inches deep.

By-law No. 14.—*With respect to the Structure of Walls, etc.*—Provides that all external and party walls shall be constructed of good brick, stone, or other hard and incombustible material in good mortar and cement.

Paragraphs 1 *to* 4.—External walls may be hollow, but width of cavity not to exceed 2½ inches, tied together every 3 feet horizontally, and 18 inches vertically, the thickness of each part not to be less than 4½ inches, or together not less than the prescribed thickness for solid walls.

Paragraph 5.—All woodwork forming head of door frames or window frames to be covered with lead.

A dwelling house not less than 15 feet away from any other building, may have external walls built of timber framing, provided the space between timbers be filled with brickwork, and have also 4½ inches of brickwork behind the timbers, etc.

By-law No. 21.—This clause deals with the method of determining the heights of storeys, and of heights and lengths of walls.

By-law No. 22.—Prescribes the minimum thickness to be allowed in every external and party wall of a domestic building.

By-law No. 23.—This by-law deals in a similar manner with the walls of public buildings and warehouses.

By-law No. 53.—Requires that an open space shall be provided at the rear of a new domestic building of an aggregate extent of not less than 150 superficial feet, etc.

By-law No. 56.—Provides that one window at least in every habitable room shall open directly into the external air, and the total area of such window shall be equal in area to $\frac{1}{16}$ area of floor, etc.

By-law No. 62.—(1) Provides for the drainage of new buildings.

(2) Drains to be of adequate size and not less than 4 inches in diameter.

(3) If iron pipes are used the drain shall be supported on piers or concrete.

(4) If other than iron pipes are used, the drain to be laid upon a bed of concrete.

(5) Drain not to be laid under a building unless other mode of construction impracticable; if drain passes under a building it shall be laid so that the depth of covering at its highest point be not less than diameter of pipe. Drains to be laid in direct lines, etc.

BY-LAW No. 63.—Provision of a suitable trap upon all drains which may directly communicate with any sewer and as near the sewer as may be practicable, with proper means of access for the purpose of cleansing.

BY-LAW No. 65.—Ventilation of drains.

BY-LAW No. 66.—As to connection to drain inside buildings, soil pipes to be not less than 4 inches diameter, which shall be fixed outside and carried to roof without diminution of its diameter, and free from all windows, etc.

BY-LAW No. 67.—Water-closet or earth-closet to be in such a position that one of its sides shall be on an external wall.

BY-LAW No. 68.—Window to be provided in one wall, whether the water-closet be within a building or not, and also means of constant ventilation provided.

BY-LAW No. 69.—A water-closet shall be provided with a separate cistern or flushing box of adequate capacity, not directly connected to any service pipe, etc.

BY-LAWS NOS. 70–91.—Position, construction and capacity of earth-closets, privy, ash-pit, cesspool, etc.

BY-LAW No. 94.—As to the giving of notices and deposit of plans for new streets, or buildings, and as to inspection.

DISCUSSION.

Mr. J. LEMON: Perhaps I may be pardoned in opening this discussion, as I was the first member of the Association to read a paper on by-laws, in the first year of our existence. I may say that my position in reference to by-laws is rather a unique one, as I prepared the set of by-laws for my own borough; I carried them out as an official, afterwards acted as a member of the council, and chairman of the works committee, and now I am in private practice. Therefore I have been able to look at this subject from all points of view, and I am still of opinion that the sooner by-laws are done away with the better. What towns want is to be placed in the same position as the chief city in the world—the city of London—and have a Building Act. That was the idea of the Local Government Board when they drew up the model by-laws. They thought we should all swallow them wholesale; we have done nothing of the kind. We all know that some of the model by-laws, if adopted, would be unworkable. They are unworkable in the town in which I live. It all goes to show that legislation is required, and legislation of the most drastic character. Various means have been suggested by which improvements could be effected, and it has been suggested that an expert committee should be appointed from this Association and from the Institute of British Architects, and the Surveyors' Institution. If we had a committee of that kind appointed, we might arrive at some solution of this difficult problem. I must say that great credit is due to the committee for the very able report they have issued. I agree with them almost entirely. One or two points I should like to refer to as to the working of our present by-laws. The extract from the report of the special committee of the Royal Institute of British Architects is to the point. That report states, "that the by-laws of many districts vary in several particulars from the model by-laws, and from one another; this want of uniformity in districts closely adjacent causes inconvenience and irritation to building proprietors as well as architects." We all agree as to that, and to the value of having the by-laws of adjoining districts uniform in character. Then the report goes on to say, "It gives useless trouble to local authorities." We agree as to that. "It multiplies, undesirably, officials to be paid out of the rates." I don't agree with that. "It adds unreasonably to the cost of building." We all agree to that. To put up an outside closet in 9-inch brickwork is absurd, and the sooner it is altered the better. Then the way in which the model by-laws are interpreted by local authorities and the Government themselves leads to increased cost of building. It says that a wall in 9-inch brickwork shall not exceed 25 feet high and 30 feet long; but it also says that the height of the wall shall be measured to half the height of the party wall or roof. You cannot get two storeys in, with an attic in the roof, without great difficulty. I do not agree that you can have a three-storey building in 9-inch work. I do not think you ought to exceed two storeys in height for a 9-inch wall. Then we require a great deal of alteration in the by-laws as to the materials which may be employed. We all know that materials are coming into use, such as ferro-concrete and other materials, which render an alteration of this by-law absolutely necessary. Again, in rural districts it is absurd to say that so long as they are sufficiently isolated, there should be a by-law to prevent the erection of wooden buildings. It is said by some that you may build a cottage on a plot of land, and that afterwards other houses may be built, and there will be danger of fire. But if the by-laws are carried out that cannot occur. These are points of importance as to the reduction of the cost of isolated buildings in rural districts. There is a point about what is a new building. Well, you know that has caused more friction, perhaps, than anything else. The new clause, suggested in the paper, is, I think, an excellent one, and will remove a great deal of friction in reference to the matter. There is another question I should like to refer to, and which is rather a burning one in Southampton, that is with reference to new buildings in old streets. The Corporation have a by-law wherein they say that the height of a building, when pulled down and rebuilt, shall not exceed the width of the street. It so happens that some of our best buildings are placed at the corner of narrow streets, and if a fire were to take place and destroy those buildings, they could not be rebuilt without being set back. I say that the by-law as to height of buildings and width of streets should apply to new streets and not to old streets, and it should give an opportunity to corporations to cause buildings to be erected in streets which are not of the width we desire. I think it is absurd to say that the building should not be rebuilt, but that you should set it back in order to comply with that by-law. I should like to propose a hearty vote of thanks to my friend Mr. Greatorex for the trouble he has taken in preparing this paper, and also to the Committee of the Association for the trouble they have taken in preparing their report.

Mr. G. W. LACEY: I have very much pleasure in seconding the vote of thanks to Mr. Greatorex for his able and instructive paper, and at the same time I should like to express the hope that the full report of the sub-committee may soon be available to Members of this Association. I am particularly anxious to receive it, because my council have appointed a committee to go into the question of the revision of our building by-laws, and I have got them to postpone the meeting until this report of our Association has been published, as I thought it would be a very considerable guide. Taking the questions raised in the order in which they are dealt with in the paper, it is proposed that exemptions from plans be given in the case of plant houses, aviaries, coal houses, and similar structures. In most by-laws exemptions are available for the buildings mentioned here under certain restrictions. I think those restrictions ought to apply in any case as to proximity to other buildings, as it allows of those buildings being constructed in combustible materials; and as to corrugated iron buildings, the Local Government Board already allow by-laws for these under certain restrictions as to size and distance from any other buildings. With regard to by-law 14, in these days of progression when methods of construction are proceeding on very different lines, there must be some provision in by-laws for walls to be put up 5 or 6 inches thick which are as strong as a brick wall of 18 inches. So far as domestic buildings are concerned, the chief difficulty is in the case of cottages with rooms wholly or partly in the roof, which are three-storey buildings in the definition of the by-law. Where the rooms entail no additional brickwork beyond 25 feet in height, then the 9-inch thickness of wall ought to apply. In some by-laws there is a provision made for that, because the by-law generally reads that a wall not more than 25 feet in height and 30 feet in length and comprising not more than two storeys, may be 9 inches thick. With the omission of the words "and comprising not more than two storeys," the walls can be built 9 inches thick, and allow of a room wholly or partly in the roof. For all habitable rooms I think the walls ought to be 9 inches thick, but such buildings as a coal house or a w.c. might be put up in 4½-inch work. If you are going to have walls in sculleries 4½ inches thick and say that cement mortar is to be used, it is placing greater responsibility on the surveyor in seeing it carried out. With regard to the walls for warehouses, etc., I think they ought to be treated on similar lines to domestic buildings. At present the by-laws require a wall to be a certain thickness at its base, but this is too vague. With regard to the sufficiency of air space about buildings, I am not in agreement with the reduction of the space at the rear. I think 15 feet at the rear of any house is little enough. With this proviso, where you have a one-storey building at the rear, reducing the present minimum space by one-fifth would leave 12 feet, and upon this there may be a w.c. and an ashpit, consequently you will have only 8 or 9 feet of garden ground left. I object also to the proposed amendment to by-law 56 as to the area of windows. I think one-tenth is a fair space to take. If you take a cottage room 10 feet by 10 feet —a very common size—a 4 feet by 2 feet window does not appeal to me as sufficient: 5 feet by 2 feet, or its equivalent, is none too large. I should like it compulsory that an inspection chamber should be provided on the drains. This is very often suggested to builders, but unless you have special drainage regulations you cannot enforce it. It is a convenience to the tenant and to the owner if any blockage takes place, as he has the means of getting to it without taking up the drain. I emphatically endorse what is said as to the submission of plans. It is absolutely necessary that plans should be submitted for all new buildings, and I do not think the Local Government Board, whatever suggestions were made to them, would strike out the by-law requiring the submission of full plans to the various local authorities.

Mr. A. C. James: I do not think the proposed width of streets too great, but I certainly think some definition should be given of what are important streets. At present, everyone knows, main streets are laid down piecemeal. Unless the councils have some means of saying how they shall be carried out, I do not think there are any means of deciding of what width they shall be made. In my opinion also the councils should have some control over the directions of main thoroughfares. With regard to by-law 21 as to the thickness of cross walls, the suggestion is made that a pillar or buttress of a length of not less than one-tenth of the height of such wall, but in no case less than 3 feet in length, be allowed in substitution for the wall carried through from back to front; but there is no suggestion of what width the buttress shall be made. That is a point which has often raised difficulties in the erection of a cottage. The party wall is usually over 30 feet in length, which necessitates the back wall of the main building being carried through as a cross wall. Frequently the chimney breasts of adjoining sculleries, which give good lateral support to the party wall, would make it less than 30 feet in length if it could be treated as a buttress. I should like to endorse the opinion of Mr. Lacey as to by-law 56, that the size of the windows should not be reduced beyond one-tenth of the area of the room. I have often been struck with the darkness of a room which had windows of one-tenth, and seeing that we are always taught that sunlight and fresh air are potent against disease, we should not reduce the amount of light. With reference to by-law 69 proposing a 3-gallon flush for water-closets, I should like to know how the difficulty would be got over that the regulations of many water companies do not allow of more than a two-gallon flush. Sometimes a two-gallon flush gives a much better result than a three-gallon flush. In the case of cottages nothing is oftener out of order than the flushing tanks, because the people who use them will not take proper care with them. Then as to plans, I should say that all plans should be properly coloured: unless that is provided for in the by-law, some difficulty might arise with persons who are inclined to be obstructionists by their refusing to colour plans properly.

Mr. E. J. **Elford**: No doubt all the Members of the Association have, for years, experienced difficulty in administering by-laws, and it has been practically impossible for individual Members to take the matter up with any degree of success. I am sure we all welcome this effort which has been made by the Committee. I should like to say in regard to the suggestion that buildings may be allowed to be constructed in wood and other materials, so as to cheapen the cost of construction, that it appears to me that the greatest difficulty is likely to arise, not in the first instance, but subsequently in the maintenance of structures of this kind. They very soon get out of repair if not properly looked after, and some regulation should be made which would prevent this. Possibly the difficulty might be met by issuing a licence for a limited period, to be renewed if thought advisable at the end of the period. It does appear that if many buildings of that character are erected, there may be great trouble in certain districts. We know that, though these buildings are sometimes erected by philanthropists, they are generally erected and maintained for profit, and people usually place the consideration of profit before any other. I should like to support the suggestion made by Mr. James as to the laying out of new streets. It does seem absurd that we should have by-laws which regulate the width of the footpath, but say nothing about the construction of the road or the essentials of construction. It is no uncommon thing for a road to be made in my district in two days. A plough is run along the so-called road in the line of the kerb, then a few loads of gravel are sprinkled on the surface of the carriage-way, and that is the road. They can at once build on a road of that kind, but subsequently very great trouble arises. I think it should be made a condition that when a public sewer is available for the purpose, the road should be sewered and that in all cases it should to some extent be made up before any buildings are allowed. In my district there are cases where sewers might have been put in, but the houses were built with cesspools, which are a great nuisance. Ultimately the Corporation has to make the sewer, after much delay and trouble. I agree that such terms as lime, cement, and mortar should be interpreted in the by-laws. That also is a matter at present in a very hazy state, and when a case is taken before the court, the result depends very much on the personal opinion of the magistrate as to what constitutes good mortar. Then I should like to call attention to the by-laws requiring the waste-pipes from sinks and gullies to discharge 18 inches from the gully. That is most objectionable. The new by-law for rural districts is preferable: "He shall cause the waste-pipe from every bath, sink (not being a slopsink constructed or adapted to be used for receiving any solid or liquid filth), or lavatory, and every pipe in such building for carrying off foul waste water to be properly trapped and to be taken through an external wall of such building, and to discharge in the open air over a channel leading to a trapped gully grating. I think the words, "over a channel leading to a trapped gully grating," might be left out, but it does appear most essential that every waste-pipe should be trapped in the building. As a rule the sink is provided with a grating, having a few small holes in it, so that the total area of the outlet is nothing like the area of the pipe, and the filth going down the ordinary sink accumulates on the interior of the pipe, and the whole of the air drawn into the house through the pipe must be contaminated. Then I should like to suggest that for sculleries 4½-inch walls are not sufficient. In some districts—my own, among others—we have in the season a large influx of visitors, and many of the houses are let in apartments. I should be sorry to say how many people occupy one house, but it is well known that in many cases the scullery is the home of the servant, and I think care should be taken that all in the house have proper healthy accommodation.

Mr. W. H. GRIEVES: With regard to the width of new streets, I do not see that any provision is made for back roads to cottage property. I think it ought to be a *sine qua non* that back roads should be provided of a width of not less than 10 feet, and in most cases they ought to be open at each end. While I agree with the minimum width of streets being 40 feet and wish it had been in operation years ago, yet I think in the case of a cul-de-sac where there are only four or five houses on each side it would be a hardship if that side street had to be made at least 40 feet wide. I think there ought to be some special provision for a street of that kind. Then I think the provision that in all main lines of communication the houses should be 25 feet from the centre of the road, but allowing owners to lay out 36 feet roads in the first instance, is a very good one, so that, if necessary at a future date, the street can be widened at a small expense. I think that would get over a good deal of the original difficulty, when landowners have to send in plans for new streets. Then the street can be easily and cheaply widened. Of course, there would have to be some provision that the local authority did not have to give too much eventually for the forecourts. As to the air space about dwellings, I am rather inclined to agree to this proviso to by-law 53, reducing somewhat the minimum air space. I know councils that have been reducing this already, and reading the by-laws in a way never intended. In cases, for instance, where there was a lean-to, which required only 10 feet of air space, and there was sufficient space over the top of the lean-to from the main building to make 15 feet, that has been taken as complying with the by-law as to air space. I have seen where difficulty has arisen in that way. As to by-law 56, in reference to windows, I do not think the window space ought to be lessened. There is another difficulty I have come across, where, in the case of a shop attached to a house, one side was practically all window, no part of which was made to open, and there was no other means of ventilation. I think something ought to be done to ensure that, in the case of a shop, proper ventilation should be insisted upon. Then as to by-law 63 with regard to drainage, I agree entirely with the suggestion as to having access by means of a manhole chamber, but I do not agree as to the provision of a vertical shaft. I think that part of the suggested clause ought to be omitted. I think every drain where an inspection chamber is necessary ought to be got at by means of a manhole. Then I also agree with the Committee's view of by-law 69, that a 3-gallon flush should be provided; I think that is little enough. When you have got a 3-gallon flush in the water-closet by the time it reaches the inspection chamber you will not find very much water going through. There is not much water for the drain, even from a 3-gallon flush, after the water closet has been flushed. I also agree with the Committee's recommendations as to by-laws 70 to 91. I think the suggestion for the provision of ashbins preferable to the unsightly ashpits we have been accustomed to in the past. But there is one difficulty I have found in my district. You must insist upon ashbins being provided before the house is tenanted, or otherwise you will sometimes find the owner is not particular about providing an ashbin. I think this is so important for cleanliness and health that it should always be insisted upon. Then the Author suggests that the deposit of plans of new buildings, and alteration to existing buildings, should be compulsory in all districts, and that they should be on tracing linen. I think that very advisable. I remember when we got our last Act in 1903—the Water Act—we got several clauses for buildings inserted, but we could not get the Local Government Board to agree with that clause. They said it was not reasonable to expect architects to supply plans on linen, and the Committee struck out the clause. I think it ought to be compulsory, otherwise, after a plan has been in the office twenty or thirty years, very often it is not possible to read it. Then I think every authority should have a complete set of plans submitted. Difficulties have arisen occasionally with reference to cornices and so forth, that have not been shown on the deposited plan. Now we make a practice of stamping only the plan to be kept filed in the office.

Mr. R. A. MacBrair: I do not propose to go into any details, but only to deal with one principle. We all know that legislation above and beyond public opinion is not carried out, and that is the reason why I think, that at the present time, we want some reasonable by-laws—by-laws which will be strictly adhered to and carried out. Local authorities should be granted modifying or dispensing powers, as cases often arise where it is impossible to carry out by-laws without exercising great and unreasonable hardships. This dispensing power was held by the Court of Queen's Bench to be *ultra vires*. But it is far better to be open and honest in the matter and grant authorities that power which they often exercise illegally. Local authorities have knowledge of local conditions; and as, broadly speaking, they have the general welfare at heart, they should be allowed to exercise their discretion in extreme cases. Some years ago my corporation wished to have the latest model set of by-laws, but thought that some of the regulations, especially those relating to timbers for cottages, were unreasonable; and as they were informed that they must "take them or leave them," they left them. In like manner did the city of Oxford. It would appear much better to educate and raise public opinion gradually, than to set up impossible "counsels of perfection."

Mr. SIMMONS: I am pleased that the Council have taken this matter up, because it is one of the burning questions of the moment. I think in framing by-laws, the question of rural and urban should be kept entirely distinct. I do not see how it is possible to reduce very much the cost of buildings in urban districts, but I think that in rural districts it is possible to reduce the cost very materially. I do not see any suggestion made as to the strength of timbers. My own council have recently taken to dispensing a new set of building by-laws, and the extravagant requirement as to timbers is really appalling. There is a general outcry against it. This is a point which I think might be taken up by the By-laws Committee. Then as to 3-storey houses. The by-laws do allow a 3-storey house to be constructed with a 9-inch wall if you do not exceed 25 feet to the wall plate. With regard to the question raised by Mr. Elford as to licences for temporary buildings, we were advised that after a building had been erected six months, it was impossible to put that in operation as to pulling it down again. I think it is a good thing, because I am afraid we should have a great deal of friction owing to people putting up buildings which would be outside the by-laws.

Mr. A. GLADWELL: I am afraid I can scarcely agree with Mr. Simmons that we should have rural model by-laws quite distinct in their provisions from those of the urban by-laws. I am afraid it is difficult to realise how very urban some rural districts are, and how very rural some urban districts are. Take my district for instance: within 20 miles of London, 70 square miles in area, 19 parishes, and 6 very considerable villages. In each of those villages absolutely urban conditions obtain, as regards the contiguity of buildings each to the other. Were we to have the set of by-laws some people would like to see in operation in rural districts, it would certainly be very difficult to deal with buildings in those urban portions of the rural districts. You would practically be allowing buildings (which I quite agree would be perfectly proper in the entirely rural area), which would not be proper in the congested part of the rural district, what I will call the urban portion. As the paper states, "what is now a country district may very soon become a very populous district." I have given the question some consideration, and it appears to me if some clauses could be inserted in rural by-laws for the area to be split up into certain zones, as regards the urban or rural character of those localities, it might possibly tend to differentiate the class of buildings which should be allowed in the respective areas or zones. I consider the rural question is quite as difficult as that in urban districts. To go from general questions to particulars, I quite agree with the recommendations of the Author as to the width for streets, and also with his suggestion that it should not be insisted upon that the making up of the entire width should be carried out until it is required for purposes of traffic. I cannot agree with the suggestion as to the construction of 4½-inch walls for sculleries, wash-houses, w.c.'s, etc., more especially in respect to sculleries. When one thinks of the difficulties in administering such a clause, with its requirement as to the use of cement mortar, and the slight difference in cost between 9 inches with ordinary mortar, and 4½ inches with cement mortar, it would appear scarcely worth considering. I certainly think that a clause should be introduced relating to constructions in ferro-concrete as well as brick and stone work. It is absurd to say that before you allow a ferro-concrete wall it should comply with the provisions of the by-laws as regards thickness as though it was in brickwork. Then I agree with several of the speakers that the suggested one-twelfth window space is not sufficient; in fact I think one-tenth is small enough. I do not agree with paragraph 4 of by-law 62. I think there is a good deal to be said against that. I think concrete could in very few instances indeed be safely dispensed with. Then there is a very important question as to the deposition of plans. I agree that plans are necessary in all cases and should be deposited, and I feel very grateful to Mr. Greatorex for the opinion he expresses that plans are even more necessary in rural districts than in cities and towns. One gets accustomed to hear rural districts spoken of slightingly. There is one point in the paper that has not yet been touched upon in the discussion—the power to charge fees for the supervision of all buildings as in London under the Building Act. I am inclined to think that is rather a valuable suggestion, because it would probably lead to the increase of salaries, a thing which we all desire. We very often find that in districts where building surveyors have been appointed, they have been appointed at a low salary, or the salary allocated to this department has been assessed at a low figure, and the work has enormously increased. If this clause could be given effect to, the repayments to the council, at all events for the work involved in the superintendence of buildings, would be in proportion to the trouble given, and would automatically register the amount of work done; and probably we poor surveyors would be able to take advantage of the increase of fees which would come in to the council, and which might be allocated to pay the surveyor for the work he does. I, in common with the other Members of the Association, appreciate the trouble which not only Mr. Greatorex but the special Committee appointed to go into this matter have given to it, and we all hope that their labours will prove of benefit in the solution of this subject.

Mr. J. F. SMILLIE: I am very much in sympathy with the proposal that we should have building by-laws applicable to the whole kingdom, but it is quite evident that that cannot prevail because local circumstances throughout the country vary so much. But it is quite possible to have a building law which would apply over the whole extent of the kingdom. I am expressing my own opinion only when I say that the model by-laws prepared by the Local Government Board are so voluminous and involved that they are really futile. By-laws in such detail have the tendency to relieve the responsibilities of builders in these matters. But by-laws which stipulate that joists shall be of certain sizes, and walls of certain thickness, without any reference being made to the weight to be carried or the strain to be borne, must be useless or even worse than that—a stumbling-block. It comes to this, that if by-laws are to be so comprehensive as that, the public will be able to dispense with the services of their professional men. I do think that those vexatious details in the by-laws should be avoided. I sympathise with Mr. MacBrair, and agree that a considerable discretionary power should be left to the local authority, because, however good may be the by-laws, there ought to be a certain amount of elasticity about them. However able the present Members of this Association may be, I speak with no disrespect to them when I say that the last words upon methods of construction do not rest with us; but seeking to have the model by-laws amended without at the same time asking that their rigidity should be removed, is practically making a claim to say the last word; for so long as they are rigid there will be little or no scope for originality in constructional details. For this reason I think an effort should be made in the direction of reducing the volume of the by-laws, and having a general building law which could be applied all over the country, and allow such by-laws to be made as will be useful to the district in which they operate. I respectfully throw out the hint; it is likely to tend to less friction between the local authorities and owners, and builders, and ultimately be to the benefit of the public, if by-laws are made more practicable than the Local Government Board model by-laws. The Local Government Board some years ago, endeavoured to force their model by-laws upon my district; but the council refused to adopt them, as they felt assured that they would prove unworkable, and, as in some other districts, be more honoured in the breach than in the observance.

Mr. C. Chambers Smith: It would have been useful if we had been informed, as it is far from clear in the paper given by the Author, as to whether the views and suggestions which are made therein, are those of the Author or of the Building By-laws Committee of the Association. I think it would have been of considerable advantage if the suggestions which the Committee framed, and which have been submitted to the Local Government Board, could have been circulated amongst the Members of the Association prior to their submission to the Board, when the views and opinions of the Members could have been obtained, and a more general enunciation of the difficulties with which they have to contend in the administration of the by-laws could have been given. It should not go forth that our Association is adverse in general to the building by-laws, for no body of men has a better knowledge of their necessity than Municipal Engineers. We may disagree in some measure with some of the details, but of the need of by-laws, in order to protect the health of occupiers, there can be, I think, no two opinions. Building by-laws, like ordinary Acts of Parliament, should have no terrors for the honest builder, whether he be the so-called owner who "builds on his own land," or the builder who erects dwellings for immediate sale, any more than Acts of Parliament relating to felony and the like should have any terror for the honest citizen. The province of this Association should be to support rather than otherwise the Local Government Board, and if we could have given an expression of opinion as an Association in favour of a Building Act applicable to the whole of the kingdom, and under which urban authorities and also rural district councils (for urban parishes) should be enabled to frame building by-laws, it would have been appropriate and in consonance with the aims of the Association. Whilst some speakers appear to disagree with the position which is taken up by the Board alone, I think it may be inferred that much of this arises from unacquaintance with that branch, viz. the architect's department of the Board which is most immediately concerned with building by-laws. Municipal Engineers will find that the officials of this department are ever ready to give them all the assistance and advice which lie in their power, and a proper appreciation of this fact will often be of value to them and the local authorities they serve. As to the suggestions made in the paper by the Author, I think there is some misapprehension of the provisions of the existing by-laws, for on page 288 it is stated that plans of plant houses, aviaries, etc., have to be submitted, and it is suggested that plans should not be submitted if the minimum area of rear space is not encroached upon. Now, in the first place, such buildings are exempted from the operation of the by-laws altogether if erected at least 10 feet distant from other buildings, whilst as to encroaching upon the open space, this is already provided for in existing by-laws under clause 54. The suggestion that an interpretation of building materials, viz. sand, lime, lime mortar, etc., should be given in the by-laws is doubtless a good one, but the Board point out the difficulty of a definition of materials which is to be applicable to the whole country. I notice that it is suggested that the term "plaster" should be defined, but the Board has pointed out repeatedly that local authorities have no power to control the "plastering" of houses, for this has nothing to do with "the structure of walls for securing stability" for which local authorities may frame by-laws under section 157 of the

Act of 1875. As to the suggested proviso to by-law 53, this clause is, I fear, too enigmatical to be understood. It is suggested that "stoneware pipes, soil pipes, etc.," should be defined and their weight given, but the Law Officers of the Crown, I am informed, advise that this cannot be lawfully done under existing by-laws. Personally, I do not agree that "concrete" is not necessary in all cases as suggested, and the clause "where the nature of the ground requires," would be so abused that it would mean in most districts concrete would not be used at all. The suggestion that windows are not necessary for outside water-closets, is not one which, I think, deserves support: for its retention means that ventilation can be obtained thereby, which is impossible with one opening, and cleanliness which is materially assisted by good lighting can be better secured. There are several other points which might be adverted to, and on which the Members present would have held opinions differing from those of the Committee, but the conclusion which I think one is able to form is that the suggestions made by them to the Board tend more towards the tightening of the operation of the by-laws and increased cost rather than to a relaxation.

Mr. J. L. REDFERN: This agitation for the modification of by-laws is largely one promoted in the interests of landowners, speculators, and builders. It is not a working man's agitation at all, and it is a question whether the workman is going to benefit. You may cheapen dwellings, but directly you cheapen them down will go the price of labour. It is not advisable for an Association like this to move except with great caution. Landowners ought to set an example by building dwellings of the best type, not of the shoddy type. I have a suspicion that the agitation on the landowner's part is to get a cheaper class of dwelling, in order to prevent the price of labour going up. I think this Association should be very careful about initiating or supporting a movement that is essentially in the interests of those who are trading on the question of dwellings for the working classes in a way which may lead to the permanent disadvantage of the working classes.

Mr. F. C. COOK: I can hardly agree with the previous speaker. I think any improvement in dwellings which will tend to keep men on the land is a matter of national importance. If the suggestion in the paper is carried into effect, and a universal Building Act adopted, we shall still need model by-laws.

It will be necessary to decide what general provisions shall be included in the Act, and the Local Government Board will be required to sanction by-laws made by local authorities to meet their own local circumstances dealing with plant houses, coal houses, and similar structures. It is suggested, says the Author, that these buildings might be erected, on permission being obtained from the sanitary authority, "so long as the minimum area is not interfered with, and the sanitary requirements are complied with, without the necessity of submitting plans, provided seven days' notice in writing is given to the local authority before the erection of such a building." Mr. Greatorex himself gives an excellent answer to that suggestion when he asks, "How would it be possible for a surveyor in a large rural district, with a limited staff, to see that the by-laws were being carried out?" I do not think it is the least hardship to anyone to have to submit a plan; we should know what the intention of the person building is before any building is begun, and a possible cause of friction would be thus averted. Then with regard to the construction of new streets, I can hardly see how the suggestion of streets of different widths could be carried out in practice. It would obviously entail a considerable hardship on an owner, if he were told that the street he wanted to lay out represented a main line of communication, and must be 60 feet wide, whereas an adjacent landowner might lay out a street on parallel lines only 40 feet wide. It does not follow that the price of the land is enhanced by the greater width of the street; indeed it might have the reverse effect. If there is to be that power in the hands of the local authority, there should be some provision included, whereby the landowners who have to increase the width of their streets might obtain compensation from the local authority for doing so. I think it would be desirable for a local authority, when considering plans for new streets, to be empowered to specify the building line to be adopted when the houses are erected. Then Mr. Greatorex says: "As regards the width of footways and carriage-ways, and the specification for street construction, these should be left to the local authority to determine in the large districts, and in small urban and rural districts the model code should be enlarged to provide for a more complete detail of the method of construction." I do not think that is at all necessary. Surveyors in small urban districts should be capable of specifying the modes of construction, without any particular method being prescribed in the model by-law. I cannot agree with the idea that out-buildings should be constructed in 4½-inch brickwork, although that may be permissible in the Midlands, where a different class of brick is used to the clamp burnt brick of the south of England. I note Mr. Greatorex omits all reference to the model by-laws as to safety in case of fire, and which form a very excellent example of grandmotherly legislation. Then again, with reference to the proposed reduction of the air space in by-law 53, is it desirable that the air space should be restricted? I think the air space is small enough, and that the tendency should be in the other direction. I admit that the by-law would be useful in the centre of large towns, but in such cases the local authority should be given power to deal with each case on its own merits. Then in by-law 69, the Committee suggests that a 3-gallon flush should be provided for. This is largely a matter of water-supply, but I think it would be a very difficult matter to induce the Local Government Board to sanction by-laws dealing with waste, etc., of water providing for a flush of less than three gallons. In connection with the giving of notices, and the deposit of plans, I think there are three or four matters which should be added. Plans should be submitted and approved before building operations are commenced; if the building is not erected within a certain time, approval of the plans should be rendered void; then it would be useful to be empowered to attach conditions of approval to plans, and a certificate of habitation should be made compulsory before buildings are allowed to be occupied. I think it is rather a pity, seeing that Mr. Greatorex has gone to a lot of trouble in this matter, that the report of the sub-committee was not circulated to Members either with or without this paper. It seems to me that the cart has been placed before the horse, and that if we had had an opportunity of discussing the report before it went to the Local Government Board, it might have had more weight when it did get there. This is the first articulate expression on the part of the Association on the matter of by-laws, and I cannot but think the proper psychological moment has been allowed to go by. We heard very little about this question until one of his Majesty's judges, who ought to have known better, popularised the subject, so to speak, by agitating against the by-laws of a certain local authority. It was rather disappointing to find that this institution and that institution were expressing opinions, and that deputations representing certain bodies with high-sounding titles had been received by the President of the Local Government Board, whilst our own Association maintained an absolute silence, especially as this is the Association which knows more about the matter than any other, and is unbiassed in its judgment. I hope some good will result from this paper. I think after thirty-three years of corporate existence, the representations of this Association ought to have some weight with the Local Government Board; and unfortunately that has not been the case up to the present time.

The PRESIDENT: While I should deprecate any notion of persons building paying fees to the surveyors for inspection, I think there would be a very great deal of advantage in making such persons pay fees to the local authorities. At present there is nothing to cause a builder to hesitate to call upon the surveyor to make as many inspections as pleases him. He will lay a few lengths of drain-pipe, and before covering them up he will call upon the officials to inspect. If a small fee were charged for these inspections it would save the time of the officials of the local authority. It would not be necessary to charge high fees for these inspections. Some of our Members have expressed fears as to the result of reducing the stringency of the by-laws in rural districts, when those districts gradually grow into urban ones. That is a matter which will cure itself. If you relax the stringency of the building requirements, it is purely conditional on there being large open spaces around buildings. When the conditions change it will be worth while to pull down those buildings and erect buildings subject to the urban requirements. That is a matter about which we need not be nervous: it carries with it its own remedy. In asking owners to lay out streets more than 40 feet in width because they happen to be main routes, we perpetrate a hardship. If we lay down a minimum width, and then require something more, we must allow compensation to the owner if he suffers any damage. Salford has or had a peculiar power. Whatever the width of a street had to be, under the by-laws, the Corporation could permit a portion of it on each side to be enclosed with the houses, and when the Corporation decided that the street required to be made up previous to adoption, the owners had to set back the fences and re-erect them without compensation. Many streets remain for many years at the narrow width at which they were laid out. There is no loss to the owners who have had the occupation for all those years of land not at the time required for street purposes. It seems to me that some such provision as that should be put in the Building Act. A suggestion has been made that streets should be made up before building. Norwich had that power, and purposely relinquished it. We found it was a waste of money. The streets were made up, then building went on, and the streets were so cut up as to require remaking. Now Norwich has nothing more than certain requirements on the lines of the model by-laws, providing among other things as to the width to be laid out for carriageway and pathways, etc. We find that builders and owners realise that people will not occupy the houses unless the street is made passable, and it is a waste of money in the original laying out to do anything further. There is a suggestion in the paper that steel work should be protected by concrete. I take it that that applies to large buildings; certainly with buildings of the cheaper class it would not be necessary to protect a framework in that way. I am one of those who very strongly support a general Building Act for the whole of the country, and each district to have its own by-laws with powers to go in matters of detail to a court of appeal for the county. It is absolutely impossible to have any by-laws that shall be applicable to all cases. Some elasticity must be made possible by having such courts of appeal to refer to. I think this will have to be a power conferred by future legislation.

Mr. A. D. Greatorex, in replying to the discussion, said: With reference to the remarks of Mr. Chambers Smith, I may say that I have not mentioned the Local Government Board in my paper at all. Purposely I did not wish to make any attacks upon the Board or its officials. I know Mr. Worsley, the head of the building department, very well indeed, and have had many interviews with him, and I quite agree with Mr. Chambers Smith in speaking very highly of Mr. Worsley and the other permanent officials of the Local Government Board. In these and other matters they are approachable, and I do not think we should blame them so much as some speakers have done. As regards certain items referred to in the discussion such as plaster, and so on, that the present by-laws do not give power to include, in the paper it is distinctly stated that the Local Government

Board should obtain the powers to give effect to the suggestion. At the present time there are two or three Bills before Parliament, one a general Omnibus Bill dealing with many clauses given to many boroughs (and that Bill is under the careful consideration of your Council), such as allowing buildings to go up before streets are laid out, as to plans being null and void if not proceeded with within two years, the flushing of soil pipes, and other matters. Then many of the by-laws have been omitted from my paper, because neither the Committee nor the Council disagreed with them. We have only dealt with those by-laws in which we suggest some amendment. As to giving discretionary powers, I think one must be very cautious as to how discretionary power is given to the local authorities or the officials. It is very easy for some officials to deal with discretionary powers, but in the case of some of the smaller authorities it might put them in a very unfortunate position. I do not hesitate to say that that official would be absolutely bound to use the discretion at the dictate of a member of the council, or perhaps an outsider, and it would be a hardship to place an official at the mercy of such a person. Many of us do exercise discretionary power—I do to-day. I am in a unique position. I have a set of by-laws made in 1868: they consist only of thirteen or fourteen clauses, such as the thickness of walls or the strength of timbers "shall be as the commissioners direct." I have never had any bother; I do not think my predecessor had any trouble during the seventeen or eighteen years he was there. But in my opinion it is better to have something definite, and then the public know what has to be done, and those who have to carry it out know what they have to carry out. As regards the proposed 4½-inch wall, we are in the fortunate position of getting a very good brick, but in building sculleries it was intended they should be built with certain mortar and certain restrictions as to height. If properly restricted, there would not be much against that. As to submitting plans for conservatories, coal-houses, and fowl-houses, there is really no necessity. Notice might be sent to the surveyor and he would send an inspector round. As to strength of timbers, that we have dealt with by suggesting certain by-laws. There are many very useful by-laws in operation in the country, which have been obtained under powers given by local Acts of Parliament. The Salford Corporation have a Building Act under which they issue a set of regulations as to thickness of walls, strength of timbers, and other matters. If a general Building Act were passed, dealing with broad principles, each council would require to have a set of regulations, and those regulations would be the by-laws, and they ought to be as uniform as possible. Take Birmingham, which is surrounded as you know by many very large towns. I daresay there are twenty different district councils round Birmingham; it is one of the most thickly populated districts in the country. I think the whole of those districts should work on identical lines. It ought not to be possible for a man to come to my office and for me to say "no"; and then for him to say "I can do it at Smethwick or Oldbury." The matter was raised in the Birmingham district, when Mr. Cook read a paper, and my friend, Mr. Price, who, I regret, is not able to be here to-day, called a meeting at his office with a view to our working on the same lines, and that has been a very great benefit. Of late there has been some agitation, and several deputations to the Local Government Board, but I think it should be remembered that this Association commenced to consider the question of the by-law amendments before there was any agitation or any action on the part of Mr. Justice Grantham. When the agitation was going on, we approached the Local Government Board as to whether they would not see a deputation from the Council of the Association on the matter. It was not necessary, they said, to receive a deputation, but they would be very pleased to receive our suggestions. I have every confidence that the suggestions of the Association will bear fruit. In view of that we can say that when copies of our report were sent to the Local Government Board, they wrote and asked for additional copies for the different departments. That shows they are not neglecting the matter.

ADMINISTRATION BY MUNICIPAL ENGINEERS.

By ERNEST J. ELFORD, M. Inst. M.E.

One of the prime essentials to the efficient administration of a municipal engineer's department is a sufficient and qualified staff. Unfortunately, some local authorities do not appreciate the importance of the former, but the Author is fortunate in serving a Corporation who, demanding a high standard of efficiency, recognise that the expenditure required to provide a sufficient staff is money well spent, and is necessary if the work is to be carried out with the greatest economy.

It is, however, of the utmost importance that the greatest care be exercised in selecting each member of the staff—from the office boy upwards—and it is the Author's practice before making an appointment to insist upon a personal interview, and to make careful inquiries as to the ability and, where possible, the personal character, of the prospective assistant.

Strict discipline is undoubtedly of the greatest advantage to both employer and employed.

In most of the larger offices a time book is kept, and each member of the staff is required to sign his name on, and to enter the time of arrival and departure. It is suggested by some that a system of this kind involves some sort of hardship, but in the Author's opinion it is of the greatest value, especially to those who have to sign.

To ensure the highest degree of efficiency, it is essential that, as far as practicable, every member of the staff should have his duties clearly defined. These should be set out in writing, and a copy handed to each man on appointment. By this means individual responsibility is fixed, the work can be fairly divided, and any shirking is soon detected.

In the preceding paragraphs the office staff has been specially referred to, but even greater care should be exercised in the selection of the outdoor staff, as they cannot be kept under such close supervision, nor can their work be checked so effectively. Moreover, in their case, any neglect of duty may remain undetected for a considerable time, with serious results.

The Author would not forget to refer to one factor, which has an important bearing upon the quality of service likely to be secured, viz., the question of salary or wages.

It is unreasonable to expect the best results from badly paid employés of any grade, and the Author has found by experience that it is the highest economy to pay even more than other people and so get the pick of the men, than to pay less and have to take what others leave.

The Author is no believer in too much red tape, but a certain amount of this useful article is indispensable in any business, if it is to be successful. Everything must be done in order, proper records must be kept, necessary rules enforced, and the details of the organisation so arranged that each individual knows his duty thoroughly and does it effectively.

One book which is neglected in some offices, but which the Author has found to be of great value when properly kept, is the "Call Book."

To ensure proper attention being given to this the Author has devised a special form of book very similar to that from which the Post Office receipt slips for registered letters are issued. Each page contains eight perforated slips, each about 5 inches by 1½ inch, and arranged one below the other. These pages are interleaved with tissue paper, upon which, by means of a carbon sheet, a copy is recorded of anything written on the slips constituting the preceding page. Upon each slip is printed the heads:

Date____________________ **Time**__________

Name________________________________

Business______________________________

Seen by______________________________

A clerk in the general office fills in the particulars, and hands the slip to the member of the staff whom the caller wishes to interview. Brief notes of the substance of the conversation are made upon the back of the slip, which is then filed. The Author has found this system very effective and useful.

A large number of the books used in the Author's department are arranged on the "manifold" principle. For instance, each of the clerks-of-works, foremen and inspectors is provided with a printed manifold report book, and is required to send to the office a daily report containing such particulars as the number of men employed, the work completed and in hand, and other details. These reports are filed as received, and the book is returned to the office when full or when a contract is completed, thus providing a complete and permanent record of the work. A form from a small special report book, printed on pink paper, is used when reporting any matter of special importance or urgency. This attracts immediate attention.

All letters received are filed on Shannon files, together with a carbon copy of the reply sent. The latter is also copied in an ordinary letter-book. By this system the whole of the correspondence relating to a given subject can be collected together in a short time.

It is important that the wages apportionment book should be very fully divided, and that it should be regularly and carefully entered up. The Author's apportionment book contains upwards of sixty columns, and although, perhaps, it is somewhat cumbersome, it is, nevertheless, exceedingly useful.

The Author has found that much time is saved by making as much use as possible of the printer. By doing so, much unnecessary writing of a repetition kind is avoided, and often greater accuracy is obtained.

Each foreman is provided with a "manifold" requisition book, from which requisitions are sent to the office. These are examined, and, if approved, countersigned by the engineer.

No orders for goods are issued, except upon official order-forms, to which are attached printed invoice-forms, which must be returned by the suppliers as soon as the order is executed. This invoice must be signed by the person receiving the goods, and after being checked by the chief clerk, it is certified by the engineer before being passed to the borough accountant for submission to committee.

A "general record" book, if properly kept, will be found of great convenience for reference. The book should contain, in concise form, particulars of the various works under the control of, or constructed by, the engineer's department.

For instance, the size, stroke, revolutions, capacity, cost, age, and other information in regard to various engines, pumps, and other machinery should be given, also the number and character of lamps, street trees, hydrants and standpipes of various kinds; the length of tramway track, size and weight of rails, points, fish-plates, bolts, bonds, and so on.

By having information of this kind always at hand, in a form convenient for quick and easy reference, much valuable time will be saved.

An important section of a municipal engineer's department is the drawing office, which, at Southend, is placed under the immediate supervision of the chief engineering assistant.

After each council and committee meeting, particulars of the drawings, etc., required are entered in a "drawing office instruction book," and it is the duty of the chief engineering assistant to see that these are prepared, and, when allocating the work, to enter into the book the following particulars, viz.:—

(1) Description of work.
(2) Date of instruction.
(3) When required.
(4) Name of draughtsman.
(5) Date commenced.
(6) Date completed.

In most cases when a drawing has been prepared in pencil, a linen tracing is taken, and from this are made photo-prints as required, the drawing being finished off afterwards.

Every drawing is numbered and indexed as soon as it is commenced, and, on completion, is filed in the plan room. The tracings are carefully preserved, so that photo copies can be taken at any time, if and as required.

Plans deposited in respect of proposed new streets and buildings are filed in linen-lined envelopes. These are 12 inches by 5 inches, each containing one set of plans, particulars of which, with the date deposited, date approved, official number, etc., are entered on the front in spaces provided for the purpose. Each of the drawings is also marked with the official number, and stamped with the date received. The numbers run consecutively, and the envelopes are filed in pigeon-holes side by side in that order. Each pigeon-hole has marked below it the first and last number contained therein, so that by reference to the index book any plan can be found in a few moments.

In the Author's borough the drains of every new house are twice tested—first by water before they are covered in, and again, on the completion of the building, by smoke. The building inspectors are required to enter regularly in a book provided for the purpose, a complete record of all visits paid to new buildings, with particulars of the size and inclination of drains, nature of foundation, size of timbers, and other details of importance.

As an adjunct to a drawing office, a camera is most useful. The Author makes it a practice to keep a photographic record of every job of importance. The photographs are taken during the progress of the work at regular intervals, and the negatives are carefully dated and indexed. A large number of photographs are also taken from time to time in connection with building prosecutions, and other litigation, and to assist in meeting objections under the Private Streets Works Act, and other statutes.

In most towns of any importance it is now usual to have annual, biennial, or triennial contracts for the supply of stores of various kinds, and of team labour. This system is probably the best yet devised, although it is not free from imperfections.

It is essential that specifications and contracts should be drawn with the greatest care and exactness, and that all goods should be thoroughly examined and tested on delivery, as, unfortunately, there are a number of firms who make it a practice to tender at cutting prices for the supply of goods of this kind, and who, having secured the contract, endeavour to make it pay them by procuring the acceptance of the most inferior and unreliable materials.

Inferior picks of foreign manufacture, bolts and nuts of low grade iron that fracture under the slightest pressure, brooms of the "best Bahia bass" (*sic*) that wear out in a week, castings of maximum weight and minimum quality, and many other articles of the cheap and nasty kind, most of which can only be detected by experienced men after careful examination are instances of this.

The contractor knows that in many cases the materials are required for immediate use, and that, if not too obviously worthless, they are likely to be accepted to avoid the inconvenience and delay which would be occasioned by their rejection.

The Author has endeavoured to meet the difficulty to some extent by stipulating that the contractor shall repay to the Corporation the cost incurred by them in receiving, testing, and returning rejected goods, and that, in addition, the engineer shall be entitled to purchase elsewhere materials equal to the quality specified, in place of the rejected goods, and to charge the extra cost to the contractor. These conditions, if strictly enforced, have a very beneficial effect.

Samples of each article to be included in the contract are provided for the inspection of persons tendering, and this saves much subsequent difficulty, though it does not entirely prevent disputes.

One of the most troublesome contracts is that for the supply of team labour. It is hardly practicable to provide a sample horse and driver, and the difficulty is not generally in regard to the carts supplied.

The Author has found the usual clause as to the rejection of inferior horses quite ineffectual. Assume for instance, that half a dozen horses are rejected on arrival in the morning. They are sent back to the contractor, whose only loss is, say, from half an hour to an hour on each horse. On the other hand, the work of the Corporation, having been previously arranged for the day on the assumption that the six hired horses referred to would be available, is disorganised and thrown into confusion, and portions have to be neglected, because by the time the defective horses have been discovered and sent home it is too late to obtain suitable substitutes elsewhere.

In consequence of this difficulty, the Author has introduced into his specification a clause stipulating that the contractor shall forfeit the sum of 2*s.* 6*d.* in respect of every horse rejected.

This has had a most satisfactory effect, as only those firms who are able and willing to supply proper horses, care to submit tenders. With such a clause, consistently enforced, there is no temptation to others to tender, and in consequence the rejections are now practically nil.

Of course, the rates charged are somewhat higher, but this extra cost is covered many times over by the higher quality and greater quantity of the work, for in this respect, as in most others, the best is the cheapest.

The Author includes as much work as possible under the piece work or "mileage" part of the contract, as he finds that, where the quantity of the material to be carted can be accurately ascertained, the work is generally done cheaper and more promptly when the contractor is paid a fixed price per unit of measurement or weight according to the distance carted.

Before commencing work each carman receives a time sheet, upon which he must enter, during the day, the particulars of materials carted, with the times of arrival and departure. A column is provided for the signatures of the sender and receiver of the respective loads. When a large number of horses and carts are hired, some means of identification should be provided. The Author causes to be issued to each hired driver, before he leaves the depot in the morning, a numbered badge which he is required to strap to the off shaft of his cart. This badge must not be removed until the day's work is completed, and must then be handed in with the time sheet for the day. The driver is then given a ticket, upon which appears the time he has worked and nature of employment, such ticket being signed by the foreman or time-keeper. The contractor knows that he should receive a ticket of this kind from each of his carmen employed by the Corporation, and that he will not be paid for more time than the ticket indicates.

Unfortunately, municipal work of the character just referred to, varies so much that most authorities find it impracticable to own all the horses they require; but from the Author's experience, he is of opinion that it is generally in the interest of the authority to keep as many horses as they can continuously employ, and to have none but the best. This system conduces towards efficiency and economy. The men are as a rule of a higher grade than those sent out by a contractor, who often hires casual labour, and they are more effectively controlled.

One of the Author's most important contracts is that for the supply of stoneware drain and sewer pipes. The Southend Corporation purchase direct from the maker all pipes of this kind required for use in their works, and issue them to the contractor where one is employed. The pipes are required to be delivered at the Corporation depot, where they are thoroughly examined and tested before being accepted. Under this system it is possible to make a more effective examination of the pipes than if they were supplied by the contractor, and sent directly on to the works. The cost of delivery to the depot is more than covered by the saving which results from dealing direct with the maker.

Tender forms for pipes, ironmongery, tools, cast and wrought iron, and other contracts covering a large number of items, contain a fixed schedule of prices, and persons tendering are required to state in their tenders the percentage above or below these schedule prices at which they are prepared to supply. This facilitates comparison and saves considerable trouble in allotting the contracts, and it is less open to the objection that those who are familiar from experience with the quantities generally used have an advantage in tendering. The harness contract is divided into two parts. The first includes the repair of all harness in use in the stables at a fixed price per horse per annum, based upon the average number of horses sleeping in the stables during each quarter. The second portion includes new harness and sundries, such as halters, bandages, brushes, combs, nose-bags, composition, and other minor requirements.

Probably many of those present have experienced more or less difficulty in securing the prompt rendering of accounts payable by an authority. The Author includes in all his contracts a clause stipulating that accounts shall be delivered by the second day of each month for the goods supplied and work done during the preceding month. Failure to comply with this requirement results in a deduction of 5 per cent. being made.

It has often occurred to the Author that something might be done—possibly by this Association—to provide, at a reasonable cost, analytical reports and expert advice as to the quality of various materials used in corporation work. The Author refers more particularly to such materials as engine and other oils, paints, red and white lead, petroleum for lighting and for use in internal combustion engines, disinfectants, varnishes, creosote and other materials, which only a qualified chemist can properly test.

Buyers of such materials are undoubtedly exposed to much fraud, and the matter is certainly of great importance to local authorities. Portland cement, stoneware pipes and a few others are generally the only materials, the testing of which engineers themselves undertake, and unless samples of the other materials supplied are submitted to a qualified expert from time to time for examination, the authority is likely to suffer serious loss. Anyone who has had much experience in the use of engine oils, for example, knows what an enormous difference there is in the intrinsic value of various samples of this material; and how difficult it is, without an analytical report, to establish adulteration and fraud. The Author is in the habit of obtaining analytical reports in respect of samples of mortar, taken under the building by-laws; and in connection with any important painting contracts he always specifies that the whole of the white lead shall be delivered on the works at one time, so that he may take samples from the bulk for analysis. This procedure is also adopted in regard to some other materials.

Much has been written and said lately in regard to the "burden of the rates." As municipal engineers are responsible for a large proportion of the expenditure of the local authorities throughout the country, the amount of these rates must be influenced to an appreciable extent by the efficiency or otherwise of the engineer's administration. The whole subject is undoubtedly of considerable importance; and although as an Association it is not our province to discuss the political or economic aspects of the question, it is both our duty and our interest to do all in our power to prevent wasteful or unnecessary expenditure, and to see that the ratepayers receive full value for their money.

To effect this, it is necessary that every item of expenditure should be carefully watched, and the greatest care taken to prevent slackness in any department.

The Author finds that the simplest and most effective method of doing this is by means of what he may term "expenditure charts." Enlarged copies of some of the charts—kept in his office—are before the meeting. Practically every branch of expenditure by the Author's department is now the subject of a chart of this kind. It will be observed that upon the chart relating to the removal of house refuse are plotted curves, representing the variation in the total cost of the work month by month and the relative cost of manual and team labour, also the number of men and horses engaged; and what is called the "estimate line," which represents the amount allowed in the estimate for the year spread evenly over the whole period; and a "population curve," which indicates, for comparison, the growth of the population.

On the "scavenging" chart are plotted the manual labour curve, team curve and total expenditure curve, as well as the estimate line. On the "steam rolling" chart are plotted the number of days worked and the cost of fuel, etc., and on the "pumping station" chart the curves represent the gallons pumped, gas consumed, and rainfall.

A glance at any one of these charts is sufficient to show how the cost compares with the estimate, and to enable the engineer to detect and investigate immediately any appreciable variation in the former. The reason for such variation is noted on the chart, so that should it be found at the end of the year that the estimate has been exceeded, an explanation can at once be given. The chart is also of value in connection with the preparation of estimates for the ensuing year.

In regard to expenditure on new works, carried out by direct labour, a prime cost book is kept. This is not only of great help in connection with the preparation of estimates, but it also enables the engineer to follow closely the cost of various jobs during their progress.

The Author has found it convenient to have two or three sets of the general conditions, specification, and quantities, relating to the various contracts in hand, bound up in cheap covers, as soon as they are received from the printers.

After the acceptance of a tender the copies of the quantities are priced out, and the whole of the documents relating to any contract are thus available for reference at any time.

The Author also has several sets of the annual tenders for stores and cartage bound in a similar manner, and priced out as soon as the contracts are let. This is found a great convenience in checking accounts, and for reference generally.

The efficient scavenging of a town is now recognised as having an important influence upon the health of the inhabitants. In organising this work, it is well to divide the town into districts, and to appoint to each a sufficient number of scavengers to work under the direction of a district foreman. Where possible, each district foreman should be provided with a small office or depot, from which his men can start work, and where brooms, tools, books, and other accessories can be kept. A drawing of the district office used for this purpose at Southend is before the meeting. It will be observed that it is about 7 feet by 5 feet, and 6 feet 6 inches high, with a desk at one end and a cupboard to contain the foreman's books.

It is convenient, economical, and satisfactory to make each district foreman responsible for reporting such matters as the following, viz. damage to carriage-ways, footpaths, street trees, or tree-guards, overhanging trees, obstructions, defective gulleys, and other matters of a like character.

In towns where a large number of street trees have been planted, it is advisable to keep scavengers supplied with a small quantity of yarn, and to instruct them to tie up any trees that may have become unsecured. By this means valuable trees may often be saved. Another matter for which the Author finds it of advantage to make the district foreman responsible, is that of openings in public roads and footpaths. Probably most of those present have had more or less trouble in dealing with this matter, and have suffered both in time and temper by having roads disturbed immediately after they have been nicely made up and repaired.

In the Author's borough, every person who desires to open a public road or path is required to pay a deposit, and to sign a printed form containing an undertaking to execute the work expeditiously and with care, and to be responsible for the lighting, guarding, and condition of the trench, and for the restoration thereof, and for any accident or damage caused thereby.

Deposits in respect of carriage-way openings are returned after the expiration of six months, if the road surface has been properly restored and maintained in a satisfactory condition during that period. The deposits in respect of openings in footpaths are retained by the Corporation, who insist upon executing all repaving work by their own staff.

Before making up a road, or executing any extensive repairs, it is the Author's practice to give notice of his intention to the gas and water companies, and others having mains, etc., in the road, with the request that they will carry out any alterations or extensions of their plant they may have in contemplation, before the road works are commenced. This often results in a saving both to the ratepayers and to the company affected.

Each of the district foremen is supplied every morning with a list of the openings sanctioned in his district on the previous day, and it is his duty to report immediately any unauthorised openings or dangerous trenches.

In many towns considerable difficulty is experienced in disposing of road sweepings, and frequently they have to be conveyed long distances. Street orderly bins are in common use as temporary receptacles for road sweepings, which are collected at intervals by ordinary carts. It has always appeared to the Author that these bins are open to grave objection. They are obstructive, unsightly, and insanitary. They are not economical, because their contents have to be handled two or three times; they cannot be kept thoroughly clean, and are in consequence often most offensive. These objections led the Author to devise a system for the collection and removal of road sweepings. A short description of it may be of some interest to the Members of this Association, as in practical work at Southend it has been found to give very satisfactory results.

For the collection of the sweepings, there are made in the Corporation workshops specially designed hand-carts—an illustration of one of which is before the meeting. It will be observed that the cart is provided with two fairly large wheels and one small one. It is also provided with a movable handle, and can when loaded be pushed and drawn by one man, on fairly level ground. It is so arranged that the handle may be replaced by a pair of shafts, the latter fitting into sockets on each side. A hopper is provided in each side for the reception of the sweepings. The cart has a sloping bottom, which enables the contents to be discharged without difficulty, when the hinged back is opened. The method of operating the system is as follows. A number of the carts are distributed throughout the town, and are moved along the streets by the scavangers, as they sweep and collect the refuse. A sufficient number of light van horses or cobs are provided for the conveyance of the carts to the tip. Each horse, after receiving a loaded cart from a gang of scavengers, conveys it to the tip, where its contents are discharged. The cart is then taken to another gang, and exchanged for the full one, which is dealt with as described. The carts follow round in rotation throughout the day from one gang to another. The principal advantages of the system are minimum cartage, minimum handling, and minimum period of storage.

The subject of street watering has been much discussed lately, as a result of the introduction of various preparations alleged to possess the quality of preventing dust.

The Author must admit that his own experience has not very favourably impressed him in regard to the efficiency of these dust-layers.

By their use the dust is certainly kept down longer than by the use of water alone, but there appears to be a tendency to exaggerate their capabilities in this direction, and, in the Author's opinion, the cost must be greater than usually stated.

Apart, however, from any question of expense, there is, in the Author's opinion, much to be said in favour of the use of water alone as a dust-laying agent. In a thoroughfare used to any appreciable extent by vehicular traffic, there must be, even on the most impervious surface, a more or less constant deposit of offensive matter, which is quickly ground to fine particles by the passage of the traffic, and which, in dry weather, becomes dust of a highly dangerous and unpleasant kind, unless the road is kept in a moist condition. This can only be done by constant watering, which not only prevents dust, but also cleanses the road surface. In addition to this, the water cools the air and increases its humidity—two effects which are both pleasant and healthful. This, of course, is of special importance in residential districts.

The maintenance and repair of roads and streets is a subject that has been dealt with exhaustively on several occasions, so that the Author will refer but briefly to the matter. During the last few years the standard of quality in regard to roads has rapidly risen, and there appears every probability that future demands in this respect will be even more exacting.

In regard to road maintenance, the Author has found that the highest efficiency and greatest economy are attained by making the district foremen personally responsible for the condition of the roads in their respective districts. It should be the duty of the district foreman to attend promptly to any patching and repairs, and he should be provided for the purpose with sufficient suitable material at convenient positions in his district. For macadam roads the patching material should be small, and the work should be carefully, skilfully, and regularly executed. If this is done the life of the roads will be very much extended. They will wear more evenly, the concussion resulting from the passage of traffic over an excessively rough surface will be avoided, and water will pass off more quickly.

The labour question is one of great importance to local authorities, especially having regard to the tendency to increase the proportion of work executed by direct labour, in consequence of which a larger number of towns employ a considerable staff of workmen of various grades, the wages bill frequently reaching 10,000*l.* to 20,000*l.*, or even more per annum. The municipal engineer has, therefore, in addition to his other duties, to manage and direct an extensive and important business undertaking.

Success in this direction can only be attained by the efficient organisation and strict supervision of labour, and by the possession of thorough experience of the value and character of materials and plant. It is somewhat difficult to deal generally with the question of organisation, as each town must be considered, to a great extent, on its own merits, in view of its special circumstances and local conditions. Perhaps the most important principle of general application is that of individual responsibility. As far as possible each man's duties should be clearly defined, and he should be given as much work as he can efficiently perform—but no more. It is generally found that the best results are obtained by placing one man in charge—under the engineer—of the whole of the outdoor work. Under this one man are district and depot foremen and inspectors in charge of various sections of work, and they, in their turn, are assisted by sub-foremen and gangers. The appointment of a supreme head promotes co-ordination, prevents friction, and saves waste of labour and materials.

The Author is aware that in some towns this principle is not followed. The work is divided into a number of more or less separate and independent departments. For instance, one man is in charge of road work, another of scavenging, another of the collection of house refuse, and so on.

Such an arrangement must, in the Author's opinion, militate against efficiency, and result in more or less waste. It means, probably, that carts are often loaded one way when they might be loaded in both directions; that one department will, at times, be paying for the removal and disposal of material which would be of value to another department; and that on occasions there is, in one department, a temporary overplus and consequent waste of labour which might have been profitably employed elsewhere.

In dealing with the subject of this paper, the Author must necessarily refer frequently to his own experience, and to the administration of his own department, but he does not wish to suggest, by so doing, that in his opinion, either of these is by any means perfect. He merely hopes that what he has said may be sufficient to promote a discussion which will be valuable to all, and from which he himself will be able to gather much that will assist him in the conduct of his work.

DISCUSSION.

The **President**: I do not think it wants any words from me to emphasise the necessity of having a proper system of carrying out the administration of the work of a municipal office. Mr. Elford has gone into the methods by which he endeavours to keep the expenses within proper limits. He shows diagrams how from week to week expenditure compares with estimates, and with previous years, and how it varies according to population and other conditions. It appears to me there is material for a good deal of discussion in this paper.

Mr. W. E. **Bush**: I should like to propose a hearty vote of thanks to Mr. Elford for his very practical and useful paper. I think that any gentleman who follows Mr. Elford at Southend, will find his task very much easier because of the excellent system of administration which he has introduced into the office there. I think that all of us who have any experience of successful contractors, or of engineering works, will know that they have a somewhat similar system to that introduced by Mr. Elford into the working of his department. We also notice it in the great railway and other companies. If this system obtains in commercial enterprises, surely to-day, when the reduction of expenditure is one of the chief points to which municipal engineers have to turn their attention, we should perfect our system of administration. I cannot enter into that part of the paper where Mr. Elford refers to the fact of having an efficient staff. The staff in my case consists of myself and one clerk so far as the office is concerned, so if I were to go in for these diagrams I should find my time very much occupied. But I do believe that the only way in which we can find out whether we are working our department in the best possible manner is by adopting some system of record books, so that we can see week by week, and month by month, what is going out in expenditure. Just lately, my waterworks committee have been worrying my life because they do not think there is a proper system of checking the expenditure on the pumping. My predecessor in office succeeded in effecting a great reduction in the waste of water, and now the members of the council think it well

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to save expense in pumping. So we have started a new system of keeping a careful record of that. I should like to endorse what Mr. Elford has said as to keeping the prime cost of work carried out. I had experience with a large firm of public works contractors, and I was forced almost against my will, to keep a very accurate set of prime cost accounts, which I had to forward to the head office at Westminster at the week end, and that meant working into the small hours of Sunday morning. But when my firm sent down a contract and asked me to price it, I found that the work was infinitely easier because of the returns of prime cost I had by me.

Mr. C. H. Cooper: I have pleasure in seconding the vote. We ought to be very much obliged to Mr. Elford for letting us into the secrets of his office in the way he has done. The appointment of staff is a thing with which one cannot take too much pains. My own staff has been appointed practically by competitive examination except in the case of the office boy, who is invariably the "boss" boy of one of the local schools. Of course, there is a good deal one cannot agree with in Mr. Elford's paper. The Shannon file, for instance, is quite an antiquated way of keeping one's letters. As to unnecessary work, we are sadly hampered by the Local Government Board. The wages book we are compelled to keep is nothing more nor less than a useless form consuming no end of time; in the case of my wages, averaging about 350*l.* a week, three days are occupied by a smart clerk on a useless abstract, whereas by means of an abstract sheet, one is enabled to get a useful abstract in half the time. As regards store contracts, such contracts may be all very well for the Local Government Auditor, but for anyone like Mr. Bush, who has just spoken, I do not think they could advocate anything of the system of stores contracts. We have stopped contracting for timber with the result that I am able now to buy it for something like 6*l.* per standard less, and firewood for 5*l.* per core less than formerly. As to monthly accounts, I do not see how it is possible to get in accounts two days after the close of the month. Then the analysis of paint; I am afraid that is not going to help very much. Paints are a perpetual trouble, and particularly a trouble to those who try every new paint that comes out. I would advise them to stick to white lead and to see that they get it. I think the Author is perfectly right as to dust laying. The proper watering of the roads, and the removal of horse droppings, are most important.

As to foremen, I do not agree that it is better to have one foreman over a department, than foremen in charge of sub-departments. The great thing in organisation is to see that every man has enough work to do, and that he does it. If you have one foreman over all, he has too much to do; he wants a lot of subsidiary help between himself and the acting foremen, and the men. As to contracts, I do not think anyone can be too particular in keeping all papers relating to contracts.

As regards team labour, I sympathise with the Author. The only thing to do is to have your own horses. For instance, take dust-collecting and road-watering. Very often you have to carry heavy loads; in the case of road watering you have 450 gallons of water and a van of 25 cwt., or a total load over 3 tons. If you put hired horses in a water van they very soon fail, but your own horses do it without difficulty day after day.

Mr. R. A. MACBRAIR: I do not quite see how it is possible to get a fair monthly average. It is all very well to take a yearly estimate, divide it by twelve, and set against it the monthly expenditure, but this does not give accurate results. Take your roads for instance; the expenses from October to March will be heavier than the other half-year. Again, rents, rates, taxes, and other fixed and heavy charges, come quarterly or half-yearly; the months without their due proportion of these items will be unduly light, and those containing them the opposite. I endeavoured years ago to carry out the system, but found it fallacious; half-yearly it can be done well, quarterly less accurately, but not monthly.

Mr. H. K. BAMBER: I think Mr. Elford has touched an important point; the desirability of an Association such as this, having some more ready and economical means of making tests of stores such as they are compelled to use from time to time, and which is a very expensive matter to do when you have to refer those samples to an analyst or expert. It seems to me that a great Association like this should have no difficulty in fixing on a central site in which they could inaugurate their own laboratory and appoint their own chemist, and to which samples of stores could be forwarded for testing. That could be done quite economically, and in that way your Association would be enabled to get the information more cheaply than you can do it now, by referring these matters to experts. I say this, having had some years ago experience in one of these laboratories in London. It seems to me that paint, white lead, and oils, and such like, should be subject to analyses. As a member of the Standardisation Committee on Cement, I realise that it is very important that the methods of testing should be carried on in a more uniform manner. Notwithstanding that every surveyor might follow his own ideas, you would have in your central laboratory, a tribunal to which you might refer in any case arising between yourself and the manufacturers of cement or any other material. It is a great difficulty the manufacturers have to contend with, that notwithstanding that the cement is supplied according to specification it is found not to be quite the same, because the methods of testing are not uniform. If a central laboratory could be founded, it would be a great advantage to your Association and to the manufacturers who are supplying all sorts of stores which you are using from week to week.

The **President**: I have been keeping a check by diagrams, of matters which could be checked, for years past. Within a fortnight after wages have been paid, I expect to find them in diagram form in my office. It takes the time clerks (two of them working at it), about half an hour a week filling up the diagrams. I think it is quite worth that expenditure of time. As Mr. Elford tells you, the diagrams exhibited on the wall were made expressly for the purposes of this meeting. What he uses every week are simply machine-ruled diagrams with the headings filled in. As Mr. MacBrair says, it is impossible to use diagrams of this sort to convey much meaning to a general committee, when dealing with work which is done intermittently. Even these diagrams are useful for keeping before you six months to six months what the expenditure is. It is so much easier to look at and compare lines than it is to look at and compare lots of figures.

Mr. E. J. **Elford**, in reply, said: In regard to the remarks made by Mr. Bush as to the amount of work entailed by the preparation of the charts, I think the President has already dealt with this point. When once you have the necessary information, it is a very small matter indeed. Once a week or month the charts have certain lines scaled on them, and an hour would do the whole thing. "Shannon" files may now be considered somewhat old-fashioned, but I still find them very useful. As to getting in accounts, we did find that contractors and persons supplying materials raised difficulties at first, but we now have much less trouble in this respect, and some months we have not an account outstanding three or four days after the time specified. As to the principle of one foreman, or a number of district foremen, I am afraid I cannot agree with Mr. Cooper. I find one supreme head over the outdoor work, however big it is, gives better results. I do not mean that a man should go into every detail, he is not there for that purpose. We, as chiefs of our departments, are not paid to do the office boy's work. We are paid at what some people think a high rate, to do work which other people cannot do as well, and I think the same applies to outdoor work. I find that a man who is competent to organise, and to overlook and co-ordinate work; to stop overlapping, and to bring all the departments into unity, accomplishes more than a number of separate units working quite independently. As to the question of stores contracts, I do not know how Mr. Cooper gets over the difficulty that the Public Health Act requires a contract for every item of expenditure over 50*l.* It seems to me that is one of our greatest difficulties. We are often unable to give an order when and where we would like to, because we must advertise and have tenders and sealed contracts. Corporations are unable in this respect to do what private persons can do. We have to let everybody know our business. Mr. MacBrair has raised the difficulty of the intermittent nature of expenditure. We at Southend have monthly statements of expenditure. All our expenditure accounts are based upon outstanding liabilities, not upon the amount of cash paid, but the amount due. The order-book is taken, and everything ordered and shown in the book is included in that month's estimate, and in regard to the charges which are paid quarterly or half yearly such as rates and taxes, the proportion of these is taken every month and added to the liability. Of course, unless that is done it is impossible to know where you are. I quite agree with Mr. Bamber as to the importance of the testing of cement. That is a matter we, as engineers, profess to know something about, but I think it is only an indication of the importance of the whole subject. We know if we specify for, say, a concrete floor, a cement to stand a tensile stress of 500 lb., and we get one that will stand only 250 lb., we are not only getting one-half of the value we pay for, but we are running a very great risk. That also applies to a great many things that we have to obtain.

ARMOURED OR REINFORCED CONCRETE.

By PHILIP H. PALMER, M. Inst. C.E.

Armoured concrete has been defined as a heterogeneous material consisting of a matrix of concrete in which is embedded a skeleton framework of iron or steel. Its use in various forms of construction has been known for many years, but it is only within the last few years that the varied problems involved in its use have been thoroughly studied and understood. On the Continent and in the United States the progress has been rapid, but in this country engineers have not, until a comparatively recent date, given that attention to this work and its enormous possibilities which it should have received; and the Author is of opinion that before many years hence, the principles of armouring concrete will have been fully appreciated, and this method of construction almost universally used in concrete structures for engineering purposes.

The laws governing the combination of concrete and steel, although not absolutely determined, are known with sufficient exactness to permit the design of nearly all classes of structures with the assurance—employing good material and first class superintendence—of permanent strength and durability.

The concrete itself plays a part as important as the steel, and the variation in the strength and elasticity of this material under different conditions has sometimes been overlooked in the theoretical study of the combination of concrete and steel. This has led to great variation and apparent discrepancies in tests made in different localities and with various materials which have been used in the concrete, and has held back the formulation of the exact principles and laws of armoured concrete.

Concrete structures when reinforced with iron or steel rods properly placed, develop a capacity for carrying loads or resisting strains several times greater than would be the case without reinforcement. It is evident that the position and nature of the reinforcement in the structure must conform to the principles of mechanics, so that the concrete shall be strengthened in its weakest part; and as concrete is comparatively weak in its resistance to tension and shear, the reinforcing metal should be placed where it will aid the concrete in carrying these stresses.

The position of the metal will vary according as the parts of the structure are in compression or tension; in beams, it should be as near to the surface on the tension side of the beam as is consistent with properly embedding it and providing a sufficient thickness of concrete to protect it from the action of heat or weather, and to ensure that the stretching of the tension surface does not result in the formation of cracks in the concrete.

As concrete is a comparatively brittle material and steel a ductile one, it is not only necessary to have a proper quantity of metal in the structure, but it must be correctly located and of good quality.

The modulus of elasticity of ordinary mild steel cannot safely be fixed at a higher value than 30,000,000 lb. per square inch, although frequently a value of 36,000,000 lb. and occasionally 40,000,000 lb. will be found.

High steel, that is steel containing a high percentage of carbon, has a much higher yield point than mild steel and may be taken at from 50,000,000 lb. to 60,000,000 lb. per square inch, and if it can be safely employed in reinforced concrete, it is adapted to carry much higher stresses than mild steel, and consequently a smaller percentage of it is required for the same moment of resistance; owing, however, to its brittleness, if of poor quality, it is seldom used for reinforced concrete.

The modulus of elasticity of concrete, a very important factor in reinforced concrete design, varies with the materials of which it is composed, and with the proportions of these materials, also with the method of mixing and placing the concrete.

As general values for use in reinforced structures, the following moduli may be taken for concrete mixed of the wet consistence usually employed:—

	Proportions.	Modulus of Elasticity. lb. per sq. in.
Broken stone or gravel concretes	1 : 1½ : 3	4,000,000
" " "	1 : 2 : 4	3,000.000
" " "	1 : 2½ : 5	2,500,000
" " "	1 : 3 : 6	2,000,000
" " "	1 : 4 : 8	1,500,000
Cinder or breeze concrete	1 : 2 : 5	850,000

These values are probably low for dense, well-graded mixtures, and are only intended to apply to concrete gauged and mixed in the ordinary way; for concrete gauged and specially manipulated, these values might perhaps be increased from 30 to 40 per cent.

The higher the modulus of elasticity of the concrete, the lower should be the percentage of steel to maintain the fixed relations between the tension in steel to pressure in the concrete. It is probable that there is an increase in the modulus of elasticity of concrete with age, but it must be very slight.

M. Considère (France) gives the stretch of plain concrete as being about 0·0001 of its length, or about 0·01 per cent.; in combination with steel, it could actually attain a stretch of twenty times this, or 0·2 per cent.; and he concludes that the stretch or deformation in the concrete of a reinforced beam may be approximately estimated from the pull or stress upon the steel, and the modulus of elasticity of the latter.

Professors Talbot and Turneaure (America) both conclude that the tensile strength of concrete may be disregarded in the consideration of the ultimate load carried by a beam. This agrees with actual practice, and with the regulations issued by the Minister of Public Works of Germany in 1904. The tensile resistance of the concrete affects the deformation and deflection of beams under the smaller loads, but if, as is customary, the working strength is taken as a definite fraction of the resistance at the elastic limit of the steel, the tensile resistance of the concrete need not be considered in the design of reinforced beams.

The strength in adhesion of concrete and mortar to steel is not only of practical importance in reinforced concrete designs, but also in the setting of bolts in mortar and concrete foundations. Tests by different experimenters upon the adhesion of smooth rods based upon the surface area of contact of the steel and concrete or mortar, show great variations, ranging from 150 lb. per square inch up to over 700 lb. The minimum ultimate adhesion for first class concrete, may be placed at about 275 lb. per square inch. It is as necessary to apply a factor of safety to this as to other stresses; the strength in adhesion is not only proportional to the area of the surface in contact, but depends upon the character of the surface and the nature of the concrete or mortar.

The depth to which the steel rods should be embedded in the concrete, varies considerably, whether they are round, square, flat, or some section of irregular surface. In reinforced structures, it is necessary to securely anchor the ends of the rods to prevent slipping of the steel, or by introducing stirrups or other vertical or inclined reinforcement. The rods should not be spaced nearer together in the clear than the sum of their two diameters, and in no case less than 1½ inch apart, nor nearer than 1½ inch to either side of the concrete.

It is of the first importance that the concrete used in reinforced design, should be composed of the best materials, properly proportioned, mixed and packed.

The principles underlying the correct proportions of the materials forming the aggregate are, that the mass when compacted shall have the greatest possible density, which will depend upon the variable degree of the roughness of the stone and sand, the relative sizes of the diameters of the stone, sand, and cement, and the amount of water used.

The proportion of cement to the aggregate depends upon the nature of the construction and the required degree of strength or water-tightness, as well as upon the character of the inert materials, and as both strength and imperviousness increase with the proportion of cement to aggregate, relatively rich or fat mixtures are necessary for loaded columns and beams, for thin walls subjected to water pressure, and for foundations laid under water.

The method employed for mixing concrete is immaterial, provided the result is a homogeneous mass of the required uniform consistence, containing the various aggregate and cement in proper proportion; and first class concrete can be produced with careful supervision, by either hand or machine mixing, and the relative cost or the use of the two methods depends upon circumstances. If the work is a small one, or if frequent moving of mixing plant would be required, concrete may be and often is mixed cheaper by hand than by machinery; there are, however, now a considerable number of small, reliable and, comparatively speaking, portable mixers in the market, so that any work except a small job would almost warrant and pay for the use of a mechanical mixer.

It is a generally accepted opinion that concrete for use in reinforced structures, should not be mixed with sea-water. At present, there is no cement or other hydraulic product which is known to be capable of resisting absolutely the decomposing influence of sea-water, and cement for use in sea-water should be low in alumina, and as low as possible in lime; a coarse sand should be used, and a small amount of Pozzuolanic material is a valuable addition to cement for this use.

The Author does not attach any importance to this opinion. In the course of the last twenty years he has used many thousands of yards of concrete mixed with sea-water, and has found no deleterious effect whatever from its use. He has also made hundreds of tests with cement gauged both with fresh and salt water, without any deterioration in the test values.

The systems of reinforcing concrete are comparatively numerous; some have been covered by patents for arranging the metal in the concrete, or for special forms of metal. Some of the systems have attained to very great commercial use, whilst others have never gone beyond the patent or experimental stage.

In 1861 Mr. Coignet began his investigations in reinforced concrete, and in 1866 Mr. Monier, to whom the invention of reinforced concrete is often attributed, applied the combination of concrete and iron to various structures, and laid the foundation for its future world-wide application.

The following are a few of the systems of reinforcement:—

Banna ..	Metal of cruciform cross-section.
Coignet ..	Round bars in top and bottom of beam, connected by diagonal wire lacing.
Cottacin ..	Round bars interlaced in the same manner as in wire netting.
Cummings ..	Bars of different lengths, having their ends bent to an incline and formed into a loop to resist internal stresses.
De Man ..	Undulated bars.
Donath ..	Inverted T beams or I beams connected by horizontal diagonals of light flat metal on edge.
Expanded metal	Sheet steel, slit and expanded so as to form a diamond mesh.
Habrich and Düsing.	Flat metal twisted hot.
Hennebique	A combination of alternate straight bars and bars with ends bent up at an angle with vertical U bars, or stirrups of flat iron, passing round the straight bars and reaching nearly to the top of the beam.
Hyatt ..	Flat plates or bars set on edge and pierced with holes, through which pass small round rods to form the cross reinforcements.
Johnson ..	Corrugated bars.

Kahn	Horizontal flanged bars with flanges sheared up at intervals.
Lock woven steel fabric	Steel wire mesh, locked at intersections.
Melan	Steel ribs, either I beams or four angles latticed, embedded in the concrete of the arch.
Monier	Two series of round parallel bars at right angles to each other.
Rabitz	Various combinations employing galvanised wire.
Ransome	Square steel rods twisted cold.
Roebling	Flat steel bars set on edge, clamped to supporting beams and held in alignment by flat bar separators.
Schülter	Two series of round bars placed diagonally.
Thatcher	Bulb bars.

The systems more frequently used in this country are the Cottacin, Expanded Metal, Hennebique, and Monier, but these and some of the others before named are used considerably in the United States and the Continent of Europe.

The application of reinforced concrete to engineering designs is becoming more general in this country, but to nothing like the rate of progress which is being made in North America and Western Europe. The Government departments of Germany and the United States have acknowledged its reliability, advantages and suitability for almost all structures; and in the former country, rules and regulations to govern its use have been drawn up by the Department of Public Works, and in both countries its study is taken up by the various professors at the Universities and Technical Institutions, and the various lending authorities readily grant loans to municipal bodies for reinforced concrete designs for periods extending to thirty years. In this country most of the work executed in reinforced concrete has been carried out in one or another of the various systems in use, for companies or private individuals, who have not to apply to a Government department for a loan to cover the cost of such work.

The adaptability of reinforced concrete for a building material is exemplified in numerous structures which, not only from an engineering standpoint, but architecturally as well, are models of the builder's art. The fire-resisting qualities of reinforced concrete appear both from experimental and actual fire-tests to be superior to those of any other material; and in fact it is doubtful if without reinforced concrete construction, it would be practicable to erect the sky-scraping structures which abound in the great cities of America, but which, it is hoped, may never be seen in this country on the same lofty scale.

The construction of reinforced concrete beams and floors in some of the large buildings in America, by comparison with the floors constructed in the usual way in this country for similar loads, show greatly to the advantage of the reinforced construction; and in Boston all new floors of public rooms and public hotels must bear a weight of 100 lb. per superficial foot exclusive of their own weight, and for floors of warehouses and mercantile buildings at least 250 lb.

As a typical example of a reinforced concrete building of large dimensions may be instanced "Ingalls Buildings" at Cincinnati, Ohio. The walls consist of concrete 8 inches in thickness faced with marble or brick. They are supported by reinforced columns spaced about 16 feet centres, and the portions of the wall at the floor-lines, that is between the top of the window of one storey and the window-sill of the storey above, are, in reality, concrete beams reinforced by two ½-inch bars, placed 2 inches above the top of each tier of windows, with ¼-inch horizontal bars 2 feet apart over the remainder of the wall. In addition to the column reinforced vertical bars are placed 2 inches from each window opening.

The marble facing is supported at each floor-line by triangular projections in the concrete, and the brickwork in the storeys above by square projections 3½ inches wide. The marble is also held at each horizontal joint by anchor bolts embedded in the concrete, and the brickwork by ties of round, straight rods about 8 or 9 inches long and ⅛ inch in diameter placed through small holes in the outer casing before concreting, so as to extend 5 inches into the concrete.

The floors above the second floor were designed for a live load of 60 lb. per square foot. The principal panels which are about 16 feet square are 5 inches in thickness, and reinforced with ¾-inch rods. Smaller panels of 3 to 6 feet in length are about 3 inches thick with ½-inch bars. The spacing of the rods varies with the length of the span.

Where the panels are approximately square, the tension rods run in two directions; and where the panels are long and narrow, the tension rods run across the panel, with ¼-inch rods about 3 feet apart running lengthwise of the panel to prevent contraction cracks. The principal girders are 32 feet long between centres of columns, and 27 inches in depth measured to surface of floor, and vary in width from 20 inches at the lower floors to 16 inches at the upper floors. Cross girders about 16 feet long and 18 inches deep, varying in width from 12 to 9 inches, are placed in the centre of the span of the main girder, thus dividing the floor into slabs about 16 feet square. The underside main girders are reinforced with four 1-inch diameter rods in the centre of the beam and two ½-inch rods on the outside of the beam and on the top side with four ¼-inch bars. The total distributed load on each main girder is about 15 tons live load in addition to the weight of the reinforced concrete.

For reinforced concrete columns, in proportions of 1 : 2½ : 5, 250 to 350 lb. per square inch, or 17½ to 24½ tons per square foot may be taken as a safe compressive strain; small columns, say under 2 feet in area, should receive rather less loading, perhaps 50 lb. per square inch less than large columns, because of the greater difficulty in placing the concrete.

Columns are reinforced by various methods: (1) small diameter rods are placed in the corners of the columns, with occasional horizontal hoops surrounding them; (2) large rods are placed in the interior of the columns to assist the concrete in taking the vertical compressive stress; and (3) some form of spiral or a succession of hoops is employed to utilise the increase in strength of hooped concrete over plain concrete. The first method, which is often used in combination with the other two, adds slightly to the actual compressive strength of a column, and assists in preventing sudden failure before the concrete is thoroughly hard.

The 1904 specifications of the Prussian Public Works place the horizontal rods at distances apart of not more than thirty times their diameters. The flexure of the column is disregarded by the Prussian regulations until the height of the column exceeds eighteen times its least diameter. Some authorities limit the height to twelve times the least diameter before taking account of this in the calculation. The Author is of opinion that where the load is eccentric (which is the case more or less with most columns) computation should be made even for short columns.

The effect of eccentric loading, that is, of having the centre of gravity of the load one side of the centre of the column, is to lessen its compressive strength.

The unit pressure to be selected for safe working loads depends not only upon the strength of the concrete as determined by its proportions, the character of the raw materials, and the method of mixing, but also upon the character and importance of the structure, the nature of the pressure—whether by direct compression or bending, whether from live or dead load or whether acting directly or through a cushion of inert material—and the time of setting before placing the load, and may range from ¼ to ⅛ of the breaking load. Although these limits may appear extreme, different conditions will sometimes warrant as great a variation in the selection of the unit pressure. A fairly safe pressure for good reinforced concrete may be taken at 625 to 750 lb. per square inch, or 45 to 50 tons per square foot at one month, of 1 : 2½ : 5 mixture. Concrete subjected to pounding or vibrating load may require factors of safety of much lower working values.

The use of reinforced concrete lends itself to the design of almost any structure, the cost in most cases being cheaper than either brick or plain concrete, and in many cases it would be extremely difficult to use any other method of construction, for foundations in bad ground, districts intersected by shallow colliery workings, and the like, with any degree of certainty in preventing settlement of the structure; and the works which have been and are being daily constructed in Germany and America appear to be, from our conservative ideas, absurdly light, yet at the same time are amply strong enough and more fitted to withstand strains than the usual solid masses of brickwork, masonry or concrete, with which we are so familiar in our engineering works in this country. The study of reinforced concrete necessarily means the study of the strength of materials and a thorough knowledge of the use of cement and concrete, which the Author ventures to think is thought far too lightly of by many engineers in this country, and does not receive so much attention as it should do; as the advantages of reinforced concrete are such as to warrant a very careful investigation of its adaptability to work coming within the scope of the civil engineer.

A description of a few examples of reinforced concrete structures may be of interest in connection with this paper.

A typical section of the Jersey City water supply conduit, constructed in loose earth, is shown in Drawing No. 1, Fig. 4; it is entirely built of concrete reinforced with longitudinal bars ¼ to ½ inch diameter, and circular hoops of ⅜-inch diameter bars, forming a mesh about 4 inches square. The thickness of concrete at the crown is only 5 inches, and at the invert 6 inches.

The canal of the Simplon (executed in 1899, for bringing part of the water supply of the river Rhone, about 2300 gallons per minute, to furnish power in connection with the driving and lighting of the Simplon tunnel) has an inner section of 6 feet 7 inches square; its walls have a thickness of only 4 inches, and the canal has a uniform fall of 1·2 in 1000. This canal is carried on ferro-concrete trestles, and is of a length of 9800 feet.

The larger portion of the New York subway is built in armoured concrete, with a framework of steel I beams; they are spaced about 5 feet apart, and the roof is formed by arches of concrete, sprung between the lower flanges of the cross girders. The concrete also covers the shell, so that it is completely embedded. The concrete is reinforced with 3-inch angles, and 1⅛-inch and 1¼-inch rods embedded.

Arch bridges in armoured concrete are common both on the Continent of Europe and in America; they are cheaper than either stone or steel, and even from an architectural standpoint may compare favourably.

The Zanesville (Ohio) bridge is composed of eight reinforced concrete arches, the largest being 122 feet span and 11½ feet rise, with a thickness at the crown of 30 inches. The arches are each reinforced with fifteen pairs of steel bars, which are ¾ inch thick by 5 inches wide for the 122 feet span, and narrower for the shorter spans. These bars are placed in two layers, one 2 inches from the intrados, and the other 2 inches from the extrados.

The Châtellerault bridge (France) over the river Vienne is probably one of the finest examples of reinforced concrete in Europe; it has a central arch of 164 feet span and 15·75 feet rise, and two side arches of 131 feet span. The thickness at the crown is about 21 inches. Each arch is formed by four separate arched beams about 20 inches wide, heavily reinforced with round rods. The floor is of reinforced concrete, and is carried by braces which rest upon the steel concrete arch. The side walks are constructed on cantilevers, and the total width of the footways and carriage road is 26 feet. (Drawing No. 2.)

A recent example of arch bridge construction in ferro-concrete in this country can be seen at Rochdale. These bridges have a span of 23 feet 6 inches with a width of roadway of 45 feet. The foundation work of the bridge is constructed on ferro-concrete piles, owing to the presence at a comparatively shallow depth of old colliery workings. These bridges were put

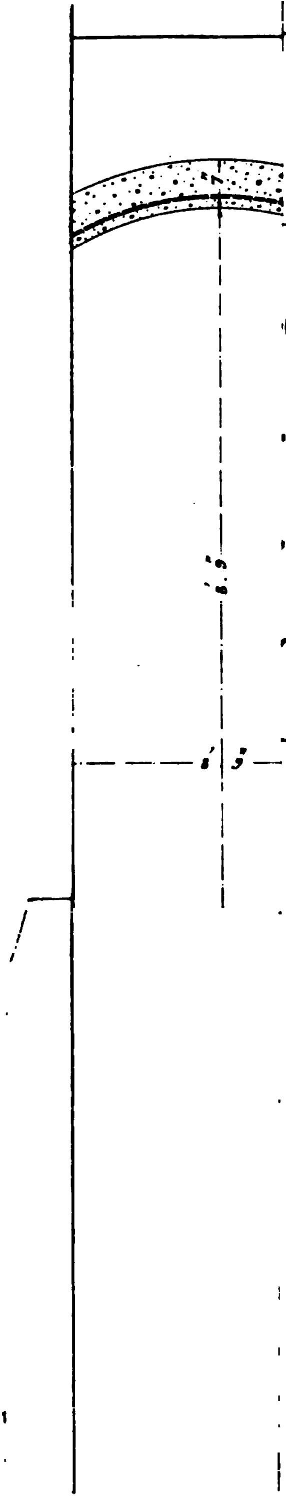

PLATE NO. 1.

RCED CONCRETE INTERCEPTING SEWER

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CITY U. S. A. CONDUIT

J. EVERETT & SONS, 19, BARTLETTS BUILDINGS, HOLBORN CIRCUS, E.C.

up under the supervision of the borough engineer of Rochdale, and have proved to be satisfactory in every respect.

Several foot bridges have recently been built for the London and South Western Railway Company in reinforced concrete, having a span of 37 feet 6 inches with a 4 feet rise, the thickness of the arch at the crown being 9 inches; the arch is armoured with longitudinal rods $\frac{5}{16}$-in. diameter 4 inches apart, and transverse rods $\frac{5}{16}$-in. diameter 8 inches apart. The strings of the stepway or staircase leading to the bridge are treated as girders, are 13 inches deep and armoured with longitudinal rods 1 inch in diameter and 1½ inch apart, each string having three rods in the bottom and three in the top section of the beam; the steps are armoured with $\frac{5}{16}$-inch diameter rods 8 inches apart. (Drawing No. 4.)

Flat bridges consisting of straight reinforced girders are quite common on the Continent of Europe, and are designed according to the principles of girder and floor design. A good example of a bridge of this construction has recently been erected at Rochdale for a length of about 100 yards, covering the river which is 60 feet wide, divided into 3 bays of 20 feet each, by two lines of ferro-concrete columns, arranged longitudinally up the river.

Reinforced concrete is admirably adapted for the construction of service reservoirs, tanks both for water and sewage, and filter beds; great care must be bestowed upon the gauging, mixing and placing of the concrete so as to insure its being practically watertight; it should be mixed so wet that it will completely cover the metal reinforcement and flow against the casing.

The new service reservoir of the Antwerp Water Company, which has just been completed, is a good example of reinforced construction, the reinforcing material being expanded metal, which has been used both in the walls and bottom.

The filter plant at the Little Falls, New Jersey, has a tank or well 41 feet high and 10 feet in diameter, which sustains the pressure of water either from within or without. The walls are 15 inches thick at the bottom and 10 inches thick at the top. Rings of ½-inch Ransome twisted steel rods were placed about every 2 feet in the centre of the wall, and vertical rods ¾-inch in diameter and about 5 feet apart, were also set in the centre of the wall, thus forming a series of hoops and posts.

At Milford (Ohio) is a stand-pipe of reinforced mortar 80 feet high and 15½ feet outside diameter. The thickness of the shell for the lower 30 feet is 9 inches, for the next 25 feet 7 inches, and for the remaining 25 feet, 5 inches. The outside face is vertical. The concrete foundation is 20 feet in diameter and 6 feet thick. On top of this, T-bars, 1 inch by 1 inch by ⅛-inch, were placed radially from the centre to within 6 inches of the outer edge, and the shell was started directly from these. The shell is reinforced with T-bars, 1 inch by 1 inch by ⅛ inch, spaced 18 inches apart vertically, and in horizontal rings varying from 2 inches apart at the base to 3 inches apart at the top.

One of the few examples of water tower construction in reinforced concrete in this country, has been erected at Bournemouth; it has a total height of 45 feet, the tank is 21 feet in diameter, with a capacity of 15,000 gallons, and the walls are 5 inches thick at the bottom and 4 inches at the top. It is supported on six pillars, each 18 inches by 18 inches, the whole structure being reinforced with steel rods.

There are numerous instances of buildings in this country which have been erected in reinforced concrete, and among them may be instanced the Southampton Cold Storage Warehouse and boiler and engine houses; the Co-operative Society's Newcastle warehouse; Weaver's Mill and grain silos, Swansea; Transit sheds for the Manchester Ship Canal Company; grain silos and flour mills at Dunston-on-Tyne.

Reinforced piles are very suitable for many classes of work, more particularly for foundations bordering the sea or rivers or in bad ground, and can be made to support almost any load; they are somewhat costly, but can be so used as to do away with more costly and bulky masses of concrete in foundations which would necessitate the use of a cofferdam and its attendant risks, or heavy timbering and excavation. Piles which are formed above ground are designed like columns, with vertical reinforcement connected at intervals with horizontal wire rods or plates. They are usually made in vertical moulds, but are equally reliable when made horizontally. It has been proved that they are able to stand repeated shock without disintegration or destroying the adhesion between the steel and concrete.

The Author has purposely refrained from introducing into this paper any of the many formulæ used in working out the stresses in reinforced designs, the location of the neutral axis or for calculating deflections at the earlier and later stages of loading; his object being rather to interest municipal engineers in a subject, which will, in his opinion, in a few years' time be well understood and in very general use, rather than to describe the various methods in use, or enter into minute details.

REINFORCED CONCRETE PILING.

By A. R. GALBRAITH, A.M.Inst.C.E.I.

In selecting the title and subject for this paper, the Author has been guided by the two following considerations. Firstly, because, after a careful review of the many appellations which are and have been applied to these methods of construction, such as "armoured," "ferro," "strengthened," and "reinforced" concrete, the last is without doubt the most suitable word to express the exact meaning that it is desired to convey when dealing with works of this nature, as it is self-explanatory, and, unlike "concrete steel," is more descriptive, and in accordance with the spirit of the Anglo-Saxon tongue. Anyhow, both terms are most widely used in England and America, and sooner or later it will become the question of the "survival of the fittest," with the probabilities in favour of the former.

Secondly, in dealing with a subject of such vast and far-reaching importance as "reinforced concrete," with its ever-increasing ramifications throughout engineering and architectural practice, it is manifestly impossible to deal adequately with it within the usually narrow limits laid down for a "paper"; and, for this reason, it is proposed to confine the scope of the present article to that extensively applied branch of this construction treating with the manufacture and application of piles to constructive works.

HISTORY.

So far as can be ascertained, M. Edmund Coignet and M. Hennebique were the first constructors to realise the advantages to be derived from applying their methods to piling. The former, who patented his piles in France in 1894, constructed them with a reinforcement of vertical rods, held in position between a series of internal and external square hooping, the outer ones being shrunk to keep the inner hoops in place. The latter engineer first applied his piles in France in the early nineties; and introduced them for the first time into this country in 1897, when a retaining wall of sheet piling was constructed at the northern end of the coal wharf adjacent to the Itchen Ferry, Southampton.

ADVANTAGES.

In addition to the usual manifold advantages that are associated with the adoption of these constructions—for instance, fire-resistance, durability, homogeneity, economy, etc.—the use of these piles in submarine work insures immunity from the dreaded attacks of the *teredo navalis* and other boring pests that destroy timber ones; and there is no serious oxidation of the metal to be feared, as in steel piles. One of their most important advantages is that, owing to their impermeability when properly constructed, they are equally durable in dry or wet soils, whereas in order to preserve timber piles they must be constantly submerged. Unlike timber and steel piles, they can be easily lengthened, shortened, jointed, altered, or repaired (the last being seldom necessary); and there are virtually no maintenance expenses, such as are inevitably connected with their timber or steel prototypes. Their most serious disadvantage is their first cost; although under favourable circumstances they will be found nearly as cheap as timber ones, and a great deal more economical than those of steel. Pile for pile, the cost will generally exceed that of timber; often, however, their adoption will mean a saving in the ultimate cost of the work—especially foundations, owing to the piles not having to be cut off below ground-water level, and the reduction of the excavation and in the volume of masonry. The concrete pile has also a much greater bearing capacity than the wooden one. In strata where a wooden pile 20 feet long, 12½ inches diameter at the the top, and 10 inches at the bottom, will carry 17,000 lb., a concrete pile, 20 inches at the top and 6 inches at the bottom, will carry 65,000 lb. This is for plain concrete; and when to this the resistance of the reinforcement in the reinforced concrete pile has to be added, it will be at once perceived that the bearing capacity is considerably in excess of that of the ordinary timber one. They are also as elastic and as resilient as timber: a pile 14 inches square, 43 feet long, suspended in the middle, gives a deflection of from 3½ to 4 inches; and they can be used for driving through strata of the most formidable character, standing a punishment that would absolutely wreck a timber pile. The ease and efficiency with which they can be connected to the reinforced concrete or other superstructure they have to support, and their freedom from vibration owing to their monolithic nature, renders them peculiarly adaptable for the foundations of piers and bridges, locks of docks, and other structures of a similar description; eliminating the heavy expenditure for cylinders, and, in the case of masonry piers, the indispensable but expensive cofferdams and pumping. In short, these piles comprise the advantages of timber piles, with some of the advantages of masonry piers; and the busy engineer will find by their adoption the solution of many problems not so easily or cheaply solved by the ordinary methods. Last, but not least, should be mentioned the facility with which the component materials can be procured or transported, and the economy of space when these piles are used for dock, quay and wharf walls, together with the ease with which such structures can be suitably anchored by means of connecting tie-rods to anchor piles driven in the adjacent strata beyond the line of pressure of the superimposed filling.

MATERIALS.

Succinctly, the materials used must be of the usual high-class description that are demanded for works of this nature and are generally adopted in these constructions. Amongst the different constructors there are some slight variations in the proportioning of the ingredients for the concrete, but, with this reservation, the following may be taken as fairly representative. The cement forming the matrix must be the best Portland procurable, fine, cool, slow setting, and of a good age. The sand must be clean, sharp, and very gritty, variously graded up to ¼ inch. The coarser part of the aggregate should be shingle, gravel, or ballast, similar to the sand, and should pass through a ¾-inch mesh sieve. Should the shingle, gravel, or ballast contain sand, these must be separated and mixed again in the correct proportions. Sometimes crushed stone is used in the aggregate, and in this case it is usual to have the very fine dust removed. The proportions used as a rule for pile work, or work where imperviousness is essential, are three of the aggregate to one of the matrix. These materials should be most carefully mixed by hand, and by machinery, with sufficient water added so that the resultant concrete is in a viscous or plastic condition.

The iron should be good ductile iron, bearing 48,000 lb. per square inch in tension before fracture, with an elongation of 20 per cent. in eight inches. The steel should be mild, bearing about 65,000 lb. per square inch, with an elongation of 20 per cent. in eight inches; and a bar of either metal, bent cold through an angle of 180 degrees, should close down upon itself without cracking.

All the materials incorporated must come strictly up to their respective standard tests, or else be unhesitatingly rejected.

REINFORCEMENT.

The reinforcement for piling naturally bears a close resemblance to that for columns. In the Hennebique type the piles are vertically reinforced with round bars, varying from 1 to 1·57 inch diameter, connected together at proper intervals with $\frac{3}{16}$-inch wire stirrups and distance-pieces, to keep the bars from spreading under vertical pressure. Rolled joists of I-section are used in the Rechten and Williams piles, and in the Johnston pile angle-irons are employed for the vertical reinforcement; while, in the Simplex pile, expanded metal is utilised for this purpose. *En passant,* it is worthy of remark that the writer has never heard of bars of rectangular section (such as are used for the horizontal reinforcement of the Hyatt and Demay systems), or of cruciform shape (similar to the Bonna system), being used for vertically reinforcing piles. The percentage of the metal varies, according to the load to be carried, from 2 to as much as 5 per cent., or even more. The round bar, which is extensively used, has these advantages: it is the cheapest, occupies the minimum space, and admits the concrete more readily into the interstices than those of more complex sections. Small sections are preferable to large ones, as there is a more equable distribution of the stresses throughout the mass of concrete; at the same time giving a larger surface for adhesion to each square inch of section. They also have the adaptability of being readily bent into any required shape. Compared with this, rolled sections present special facilities for joints and junctions, and are self-supporting prior to the application of the concrete, although they require increased labour in placing them in position; and, in the event of failure of the concrete locally or entirely, through either bad materials or workmanship, they are usually calculated so as to be strong enough to carry the load irrespective of their enveloping medium.

Without exception the most efficient method of column reinforcement is the helicoidal hooping of M. Considère, and this will undoubtedly (if it has not already been done) be soon applied to pile work. Fig. 1 is a rough vertical and horizontal section, showing the arrangement of the hooping and the other reinforcement for these columns. The vertical bars are invariably of small section, and are introduced to increase the rigidity of the column by their resistance to flexure. M. Considère, in some of his later experiments with columns some 12 months old, reinforced in this manner, obtained a compressive resistance of nearly 12,700 lb. per square inch before failure by crushing. Now, according to M. Christophe, the compressional strength of concrete is equal to 700 lb. per square inch, and allowing, say, a factor of safety of 2 as the minimum for structures of a permanent character exposed to heavy moving loads, this would give 350 lb. per square inch for columns or other members subject to compression and reinforced in the usual way. With hooped concrete the loading can safely be increased from this amount up to as much as, say, 2000 lb. per square inch—an immense difference. The percentage of metal used is also considerably less than that for the longitudinally reinforced columns, although the labour connected with the former is probably slightly in excess of that for the latter. This method of reinforcement is peculiarly suitable for a pile of circular section, and such a pile would offer very great resistance to oblique strains. All metal should receive a liberal coating of Portland cement grout before being embedded in the concrete.

Load on Piles.

Theoretically, piles can be considered as analogous to columns with the following additional considerations: in estimating the dimensions of the reinforcement for the load a pile will have to sustain, it is usual to assume the maximum loading it will be called upon to bear in the driving operations.

Let W represent the load,
Q „ weight of the ram,
f „ fall of the ram in feet;

$$W = Q \times 8 \sqrt{f} \quad . \ . \ . \ . \ . \ . \ . \ . \quad (1)$$

Ritter's formula is generally used to ascertain the supporting power of piles after driving.

If W represents the load in lb.
Q „ weight of the ram,
q „ weight of the pile in lb.
h „ height of the fall in inches,
e „ final penetration in inches;

then

$$W = \frac{h}{e} \cdot \frac{Q^2}{Q + q} + Q + q \quad . \ . \ . \ . \quad (2)$$

On the value of W being determined, it must be reduced to the safe bearing load, with an allowance of a factor of safety of 10.

e varies, according to the nature of the strata, from about 0·25 to 0·10 inch, the former value sufficing under ordinary circumstances.

The weight allowed for reinforced concrete on the Continent is 2500 kilogrammes per cubic metre, or 155·5 lb. per cube foot.

MOULDING.

There are three methods of manufacturing piles:—

a. In vertical moulds supported by frames.

b. In horizontal ditto.

c. In a special apparatus such as a "driving form," the piles being then formed *in situ*.

It is only proposed to describe here *a* and *b*, *c* being deferred to the description of "piles built *in situ*."

When piles are moulded vertically, the moulds are built in stout timber frames, the internal section of the mould corresponding to the size and shape of the pile. The working faces of these moulds are left open: cast-iron or steel shoes are then placed in position at the bottom of the moulds, and attached by wrought-iron straps to the bottoms of the piles (Figs. 4, 5, and 6), these straps being bent over inwardly at their extremities to form a key with the concrete. The vertical bars are then carefully adjusted to the fiduciary line by gauges to within an inch or so of the casing, and kept in place by the connecting stirrups and distance-pieces dropped over the bars from the top to different points marked on the edge of the moulds, varying from 2 inches at the bottom and top to 10 inches at the centre of the length of the pile. Concreting is then commenced, a bucketful at a time, which must be thoroughly well rammed as soon as placed in the mould; and as the height of the pile increases, the working face of the mould is closed by shutters from 4 to 6 inches deep, running in grooves formed in the sides of the permanent casing. The faces of the moulds should be invariably well soaped or white-washed, in order to prevent any adhesion of the concrete to the woodwork. Concreting should, whenever possible, be continuous until the particular pile is finished; but when this is not done, care should be exercised to remove any loose or foreign material from the surface of the old work, and it should then be thoroughly cleansed and afterwards serrated with a cutting tool. Pure cement grout should then be poured over its surface, and the work resumed as before. Vertical moulding, especially when the piles are of great length, is extremely troublesome and expensive, although the concrete has, as a rule, a greater and more uniform density.

Piles are moulded horizontally in suitable framing-boards, held together by special clamps and timber cross-pieces (Fig. 2). The clamps are formed of two pieces of rectangular iron, the longer piece being bent over at right angles to its length, its extremity being carried over so as to project for a short distance in a line parallel to its longer length, and terminating in a metal button. The shorter piece is made of similarly shaped iron, with a similar extremity sliding on the longer one so as to be adjustable to the size of the mould. The clamp is tightened by hammering up the straight projecting end of the shorter piece, and the loosening effected by the reverse process. On the reinforcement being in its proper position, concreting is commenced in a like manner to that adopted for the vertical process, the inner faces of the moulds being treated as before described to prevent any adherence to the concrete. This method, although much more economical than the vertical one, has the drawback that even with the greatest care there is a great liability of the occurrence of inequalities in the density of the concrete.

After about 38 hours the concrete is sufficiently set for the moulds to be stripped; and the piles are then allowed to remain, from 28 to 40 days, to set preparatory to driving.

DRIVING.

The piles can be driven hydraulically, or by the ordinary pile driver, or a combination of both. When the nature of the strata will permit it with advantage, they can be driven with the water jet, and for this purpose a ¾-inch gas pipe is carried down the centre of the pile, terminating in a ⅜-inch nozzle at the point of the shoe. Sometimes it is more convenient to introduce this pipe at the side of the pile (Fig. 5). Experience shows that a heavy ram, with quick successive blows and short drops, gives the best results. In order to distribute the impact stresses uniformly over the top of the piles, the head is encased in a steel cap (Fig. 4) filled with sand or sawdust, a tight joint of hemp and clay being made between the lower part of the cap and the pile to prevent the escape of these materials. A timber dolly is generally interposed in the usual way between the ram and the pile head, and a separate cap is required for each size of pile. Fig. 3 portrays the method adopted at Chantenay-sur-Loire, Nantes, France; the relative positions of the different parts being clearly shown. In this instance the piles were made of plain concrete tops, designed to be broken off sufficiently after driving to expose the reinforcement for connection to the superstructure. This arrangement allows of the upper portion of the pile being loosely clamped to the guides of the driver. These sheet piles, 11·8 by 14·8 inches in section, were driven by a 3520 lb. ram, with a fall of 6·25 feet. As an example of the excessive weight of the ram, compared to those for driving ordinary timber piles, the 16 inches square reinforced concrete piles of Hennebique design for the Brumath Bridge were driven with an 8800 lb. ram, with a maximum drop of 8 feet. The driving rig is similar to that employed for driving the ordinary timber piles, with the exception that stronger tackle is required to handle the heavier reinforced concrete pile.

PILES.

For the sake of convenience, piles can be suitably classified under two heads, i.e.:—

a. Piles moulded or cast prior to use.

b. Piles built *in situ.*

MOULDED PILES.

The first are now extensively used in this country, but the second have yet to receive the attention here that is their due. Moulded piles are invariably rectilinear in section, and, with but a solitary exception, quadrilateral. It seems strange that the circular section has been avoided in this type, because such a form would have, under certain circumstances, obvious advantages over those of rectilinear shape, although, owing to the greater complexity of the moulds and the reinforcement involving extra labour, they would be more expensive to construct.

REINFORCED WITH ROUND BARS: HENNEBIQUE TYPE.

Foremost amongst these are those constructed according to the Hennebique system. Fig. 4 is a typical example of a Hennebique bearing pile. These piles are square in section, with a pyramidal point, the top being shouldered off and terminating in a circular head to receive the driving cap. The reinforcement consists of four soft iron rods, placed at the corners, and wired together at the intervals previously stated. Fig. 5 is a half-sectional elevation of a bearing pile, showing the arrangement of the vertical and horizontal reinforcement. It also shows the jet pipe used in driving, and sometimes resorted to as a means for forcing grouting into the ground immediately contiguous to the point of the shoe when the pile is in its proper position.

Sometimes six reinforcing bars are employed, and Fig. 6 is an example of those used in the construction of a wharf at Noverossisk, Russia. They are 15·75 inches square, and designed to carry a safe load of about 38½ tons, in addition to the dead load represented by a section of the wharf floor having an area of 269 square feet. Their weight is about 262 lb. per lineal foot, from which 45 lb. per lineal foot can be deducted for the reinforcement. Bearing piles on this system have been made in lengths up to 62 feet, and a sectional area 16 inches square will carry a safe load of 50 tons.

In the sheet piles six bars are also used, Fig. 7 depicting the disposition of the steel work and drifted shoe. These piles are also fitted with a semicircular groove on either side, which extends from the upper end of the shoe to the top of the pile. At the lower end of the pile, on its longer side, is fixed a metal spur, which fits into the groove of the pile preceding it (Fig. 7), and acts as a guide in driving. After driving, these grooves are carefully cleaned out with the water jet and filled with cement grout, making a perfectly watertight joint, forming the series of piles into a solid monolithic mass.

Fig. 8 is yet another variation in the shape of piles reinforced with round iron bars tied together with wire stirrups. These piles were used in the construction of the foundations of the new law courts at Berlin-Wedding. In transverse section they represent an equilateral triangle with bevelled edges, reinforced with iron bars 1 inch in diameter, connected together at regular vertical distances of 10 inches by ¼-inch wire eye-bars, set into the concrete with a blunt point at their lower end. At the bottom of the pile the three bars converge to a point, and are welded together. The proportion of the concrete was one of Portland cement to three of river gravel. This concrete, slightly wetted, was carefully prepared in a pug mill, and deposited in vertical wooden moulds in layers 8 inches in thickness, which layers were afterwards compressed to about half that amount. Prior to fixing the ties and adding fresh concrete the surface of each preceding layer was roughened, so as to ensure a thorough homogeneousness of the whole mass. The piles were then left for a period varying from twelve to twenty-four hours, and for the following seven or eight days were frequently and copiously watered. They were then removed from the moulds, and again watered for eight or ten days, being then sufficiently hardened for transport to the works, where they remain for about a month longer, and are ready for driving. They were driven by a steam pile-driver through poor and treacherous soil, with a ram weighing 2½ tons, falling 5½ feet. Their length varied from 17 to 26 feet, and, to prevent their heads being damaged by the ram during driving, they were protected by a buffer built up of sheets of lead, plates of iron and timber packing, all held together with an iron ring.

HOLLOW PILE: MOUCHEL'S.

M. L. G. Mouchel, the pioneer and representative of the Hennebique system in this country, has introduced and patented a light hollow pile (Fig. 9), vertically reinforced with iron bars of circular section, to which are connected at the required intervals the horizontal reinforcement, consisting of iron diaphragms, distance-pieces, and wire ties. The cavities in this pile are formed of concrete moulds, built in during manufacture. They are lighter and equally as strong as the other piles, and therefore offer special facilities for handling and transport.

When any of the piles reinforced with round bars are of insufficient length, or a joint or junction has to be formed, extra bars can be added by overlapping them for a distance equal to 24 times their diameter. Another method is to cut off the ends of the rods die-square, and abut them against one another, adding a sleeve of iron tubing over the joint, thus insuring a uniform resistance. The tops of the reinforcing rods are usually covered with about 1½ inch of concrete.

REINFORCED WITH ANGLE-IRONS: JOHNSTON PILE.

Mr. Andrew Johnston, of the Armoured Construction Company, has patented a reinforced concrete pile, the salient features of which are the vertical reinforcement of 2 inches by 2 inches by ⅜-inch steel angle-irons, connected to 1¼-inch by $\frac{3}{16}$-inch iron bands and to ⅛-inch steel wire diaphragms, the latter being designed to counteract the shearing stresses (see Fig. 10), which sufficiently explains the patentee's arrangement of the reinforcement. The lower end of the pile terminates in a steel shoe. These piles are from 40 to 50 feet in length, and 18 inches by 12 inches in cross section, the reinforcement being 2 inches from the surface of the concrete. They were designed for a wharf on the Thames at Rotherhithe.

REINFORCED WITH I-BEAMS: RECHTEN PILE.

The piles of the Rechten, Vereng and Dopking system are reinforced with rolled steel joists framed together. Fig. 11 is an example of such a pile, employed for a quay wall. The reinforcement consists of two parallel **I**-beams, connected at intervals of 7·7 feet with plate and angle cross-ties. One of the narrow faces is grooved, and the other has a tongue for the purpose of interlocking with the adjacent piles when employed as sheeting. An anchor rod, shown at the top of the pile in the diagram, is connected to a massive concrete anchor buried in the firm ground at the rear of the quay. In driving, a timber dolly or false pile is used, with a hemp cushion interposed between the dolly and the pile head in the usual way. These piles are generally moulded horizontally; but in this case, whether horizontal or vertical moulds are introduced, it must be equally difficult to well ram the concrete around the reinforcement.

WILLIAMS PILE.

Mr. A. E. Williams, of Dagenham Docks, Essex, is the inventor and patentee of a pile in which the vertical reinforcement is composed of a rolled steel joist (9¼ inches by 4 inches, weighing 20½ lb., in a 14-inch by 14-inch section) embedded in concrete (Fig. 12). This joist can be fitted with a cast-iron shoe, but it is considered preferable to cut a triangular piece out of the web of the joist, and then bend the flanges in until they meet, cutting off the corners to form a point. The concrete is further strengthened horizontally, at about intervals of 1 foot, with rough hoops, 11 inches in diameter, formed of $\frac{3}{16}$-inch steel wire. The weight of a 14-inch by 14-inch standard pile is about 2 cwt. per lineal foot. When flexure is likely to be set up by oblique strains, acting at right angles to the web, they are stiffened by the addition of two flat steel bars on either side acting as trusses (Fig. 13). These bars can be curved if desired, and their addition entails an extra cost of only 3*d.* per foot cube. To facilitate the handling of the piles, three holes are drilled at different points on the centre line of the web, extending right through to the surfaces of the concrete, and lined with 2-inch boiler tubing. The first of these, which is also used as a gauge bolt-hole, is situated about 2 feet from the top of the pile; the second and the third being placed at points one quarter of the length of the pile on each side of the centre respectively. These holes are used for slinging the piles into a horizontal position, making it possible to handle them within seven days after manufacture. The concrete is compounded of clean shingle, which has been rejected by a ¼-inch but has passed a ¾-inch mesh sieve, mixed with half its volume of clean, sharp ¼-inch sand. This is mixed dry with 200 lb. of Portland cement to every 9 cubic feet of the aggregate, it is then sprinkled with water, turned over by hand, and afterwards passed through a special form of pug mill, until the concrete is in a plastic condition, and it is then ready for use. Joints are formed by breaking away the concrete from the joists for a depth of about 18 inches—to this is added a piece of joist of the required length fished to the infra-incumbent pile. Moulds are then framed round, and the concrete is rammed in, making a continuous pile from the point to the top of the work. For driving, a 2-ton ram, falling 6 or 8 feet is used; and the heads of the pile are protected with a temporary cast steel cap, above which is a hardwood dolly about 3 feet long.

PILES BUILT IN SITU.

Piles of this description have not yet been introduced, so far as can be ascertained, into this country, although they have been and are being applied in America with much success. The essential feature connected with these piles are the "driving forms," or shells described hereafter in the two methods dealt with, i.e. the "Raymond" and the "Simplex." Up to the present the piles constructed according to these systems have been of concrete *in toto*, but they can be easily reinforced by the addition of a simple reinforcement when so required.

REINFORCED WITH ROUND BARS: THE RAYMOND PILE.

Fig. 14 is an illustration of the reinforced concrete pile manufactured by the Raymond Concrete Pile Company, of Chicago, Ill. This pile is usually made of a uniform taper throughout, and is vertically reinforced with a 1½-inch round bar placed in the centre of the pile, and of three smaller bars, generally about ¾-inch diameter, equidistantly spaced about the circumference.

The apparatus used in casting these piles is of an elaborate nature, consisting of a tapering collapsible driving form, jacketed

PLATE NO. 1.

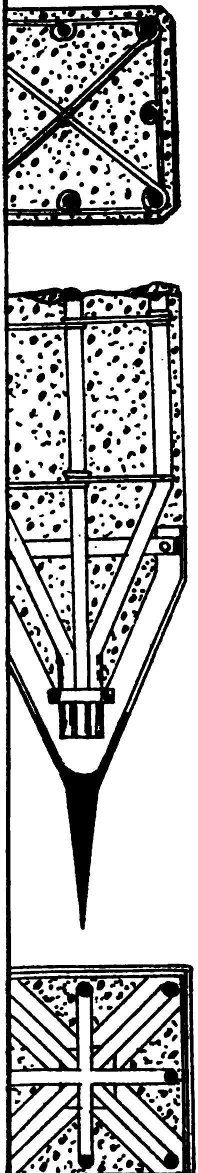

Fig. 6.

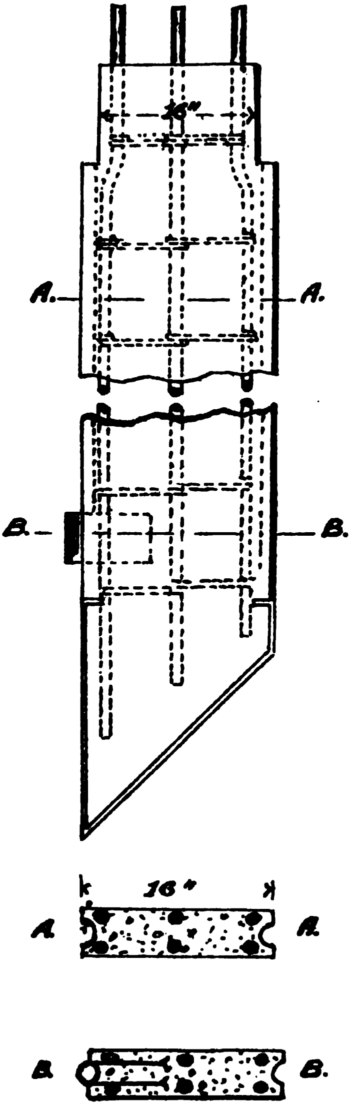

Fig. 7.

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with a shell of steel plate, which is first driven into the ground, and then withdrawn leaving the shell in place. This form is made of two longitudinal halves of cast steel, between them being fitted a key of the same metal provided with wedge-shaped lugs. These lugs keep each half of the form apart during driving, and a horizontal key slipped through the head keeps the three different pieces in position. The shell is then adjusted over the expanded form, and the combination is driven with a steel driving cap placed over the head of the form, and supplied with horizontal pieces running in the guides of the pile driver. On the completion of the driving operations, the key is raised until the lugs fall into the recesses formed on either side of the form halves, thus allowing of the withdrawal of the form from within the shell. When the form is in position the reinforcement can be arranged as previously mentioned, and the space gradually filled with concrete.

Owing, however, to the heaviness and mass of the collapsible form, they are found not to drive easily with an ordinary ram, and for this reason recourse is had to the water jet whenever possible. Their cumbersomeness, according to Capt. J. S. Sewell of the U.S.A. Corps of Engineers, renders them impracticable in some situations, and there is but little doubt that the great difficulties of their manipulation limit their employment to depths of less than 40 feet.

The piles for the foundations of a library building at Aurora, Ill., were constructed on this system, without any reinforcement. They were 20 inches in diameter at the top, tapering to 13 inches at the bottom; and were driven by an ordinary pile driver, through 14 feet of made ground overlying rock, with a 2400 lb. ram, having a drop ranging from 20 to 25 feet, the penetration at each blow being from ½ to 2 inches. The form used was made of No. 20 sheet iron, and the concrete was 1 part Portland cement, 2 parts sand, and 4 parts broken stones.

REINFORCED WITH EXPANDED METAL: THE SIMPLEX PILE.

This pile was introduced by the engineers of the Simplex Concrete Piling Company, of Philadelphia, Pa. When these piles are reinforced, expanded metal is the medium adopted. It is employed in the form of a circumferential cylinder of this metal, of 3 inches mesh, and $\frac{5}{16}$-inch in thickness (Fig. 15). Fig. 16 is a longitudinal section of the apparatus used in driving these piles where water has to be encountered; but when this has not to be feared, the outer shell shown in the illustration is dispensed with. It consists essentially of a wrought-iron shell or tube, the internal section of which corresponds to the length and diameter of the size the pile is to be. To the lower extremity of this shell is affixed a previously cast concrete shoe, which is then driven, surmounted with a hardwood cap, by means of an ordinary pile driver to the desired depth. On the completion of this operation the expanded metal reinforcement is adjusted in the interior of the shell, with its lower end abutting on the concrete shoe. The shell is then gradually withdrawn as it is filled with concrete, until, the process finished, it is entirely free. When the outer shell is employed in water or water-bearing strata, it is made long enough to penetrate the bottom a sufficient distance to prevent the percolation of water into the hole. It is driven together with the inner shell, the latter being withdrawn leaving the outer shell in place by unfastening the clamped collar by which they are connected together. This shell is left permanently in its position, and forms the metal for that part of the pile exposed to the action of the water.

Piles of this description were employed in the construction of the extensive foundations for the engineering school at Washington barracks, District of Columbia, under the superintendence of Capt. J. S. Sewell and Lieut. C. S. Smith, the army engineers in charge. The site of the building consisted of materials of a varying nature, being on the surface a yellow loamy clay, and, 4 to 5 feet below this, a fairly dry and solid stratum of blue silt, while below this again were beds of wet sand and gravel. On experimenting it was discovered that, in consequence of the layer of blue silt, the surface clay would only sustain the small bearing load of 500 lb. per square foot without serious settlement, and as the subsoil is alternately wet and dry, owing to the variations of the level of the waters of the Potomac river adjoining, timber piling was precluded.

In the concrete piling the forms comprising the shells are 11 feet long, and made of boiler steel $\frac{3}{8}$-inch thick, these same shells being used throughout the whole of the work, needing only casual repairs to the rivets, etc. The interior shell was composed of a 10-inch cast-iron pipe, the lower end of this pipe fitting over a tenon round the upper portion of the concrete shoe, the upper end being crowned by a black ash driving-cap, so placed as to drive the combined shells. The whole arrangement was driven with a ram weighing 2200 lb., falling 10 feet, the final penetration averaging about ⅓ inch, the shoe being then embedded in the sand. It was found as a rule that the shock of driving fractured the tenon of the shoe, it being generally brought up on the withdrawal of the driving form. This had its advantage, inasmuch as the freshly-broken surface made a good bond between the upper portion of the concrete shoe and the superimposed concrete.

The concrete for the shoes was proportioned by volume of 1 part of vulcanite Portland cement, 2 parts of concrete sand, and 5 parts of broken stone, including run of crusher. That for the pile shafts was compounded by volume of 1 part of old dominion Portland cement to 3 parts of concrete sand, and 5 parts of gravel. Enough of this concrete was placed in the shells at a time to form a layer 12 inches thick, each layer being then rammed, and the shell so gradually raised that there was never less than 6 inches of concrete remaining at its bottom.

In driving it was found that the piles could be built so that their centres coincided well with the points staked out, although occasionally, in consequence of encountering a boulder, a variation of 3 or 4 inches from the perpendicular would occur, but this fault could generally be rectified on the withdrawal of the shell.

Some piles were constructed 17 inches diameter and 35 feet long, for driving through soft dry blue silt underlaid with sand. The forms employed were entirely similar to those described, except that the metal was ⅝-inch thick instead of ⅜. After driving they were found very difficult to withdraw, owing to the great friction on their exterior surface, but this was overcome by applying a lubricating coat of grease or heavy oil prior to driving. Some of these piles, 16 inches diameter, driven through 40 feet of mud and sand, were loaded with as much as 26 tons, with a settlement not in excess of a ¼-inch, although they had carried the load for several weeks.

The experience with these piles at these barracks indicated that where the excavation was required to be as deep as 10 feet, even if at that depth a hard bottom was found to exist so that wooden piles were dispensed with, the use of concrete piles was economical by the avoidance in unstable ground of deep trenches with their solid concrete filling.

COST.

The incessant fluctuations in the cost of materials and labour in various localities, and the different conditions affecting the driving, renders it impossible to give any information regarding prices which can be generally applied, and the following prices are therefore given, with due reservation, simply for the purpose of an approximate guide.

Piles of the Hennebique type, 12 inches square, have been driven at a cost of 4*s.* per foot cube; and it has been stated that the Williams standard pile, 14 inches square, can be manufactured and sold at as low a figure as 4*s.* per foot cube. The prices quoted hereunder are for some Hennebique piling driven in several places in the south of England:—

Woolston ..	10	inch	by	10	inch	piles,	8*s.* 6*d.*	per foot	cube.
Gosport ..	12	„	„	6	„	„	4*s.*	„	„
Portsmouth	14	„	„	14	„	„	6*s.* 6*d.*	„	„

EXAMPLES.

Before concluding, a few examples of the methods of applying reinforced concrete piling are here given.

Example I.—Building Foundations.

Figs. 17 and 18 are transverse sections of the reinforced concrete foundations for the ten-storey steel-framed Hallenbeck building at Park and Pearl Streets, New York City. The old portion of the structure had wall-columns carried on I-beam grillage foundations, buried in the concrete caps of the timber piling, the extension of the building covering a space of 102 feet by 20 feet. These piles are 12 inches square, 28 feet long, reinforced by four $1\frac{7}{16}$-inch diameter steel bars, connected together with stirrups, etc., as detailed in Fig. 5. They were formed in horizontal wooden moulds of 1 : 2 : 4 Portland cement concrete, the stone being $\frac{1}{2}$-inch crushed trap rock. After driving, the tops of these piles were broken off for a distance of 5 inches from around the reinforcement, for the purpose of connecting them to the foundation mattress, 16 inches thick, also composed of concrete efficiently reinforced with a reticulation of steel bars, and superimposed at a height of about 6 feet above ground-water level.

The piles were calculated to sustain 80,000 lb. apiece, including 36,000 lb. per square foot in accordance with the New York building regulations for concrete piers; besides an extra load of 44,000 lb., assumed to be taken up by the four reinforcing bars, these regulations allowing 7000 lb. per square inch as the safe compressional working load for this material.

The test borings showed that if timber piles had been employed it would have entailed excavating beneath the wall footings of the adjacent premises, as well as underpinning their foundations and carrying them down to a greater depth; all the heavy expenditure that would have been necessitated thereby having been obviated by the adoption of the reinforced concrete piles.

Example II.—Bridge Foundations.

Fig. 19 is a vertical section and half plan of the reinforced concrete pile foundation and pier of the Brumath Bridge in Alsace-Lorraine. This construction is completely of Hennebique design, and is a good example of the monolithic nature of the work that ensues from the practice of continuing the reinforcing bars from the piles right up through the pier into the superstructure. These piles were 14 to 16 feet long, and were driven through about 6½ feet of swamp mud underlaid by coarse gravel. The fall of the ram during driving varied from 2½ to 4½ feet, the initial penetration being 2 inches, and gradually decreasing to about 0·4 inch.

Example III.—Pile Foundations in Hard Rock Bottom.

Fig. 20 portrays the arrangement of a jetty construction on a hard rock foundation. A hole is primarily drilled or blasted in the rock to receive the end of a reinforced concrete pile, which is moulded hollow. Steel bars are then lowered into the hole in the rock through the central cylinder of the pile, which is afterwards filled up with rich cement concrete. The openings depicted at the base of the pile are for the purpose of allowing a sufficient quantity of concrete to escape, thus forming about its foot a block resting on the surface of the rock, and, the steel bars being entirely buried at their upper extremities in the concrete, the pile becomes securely anchored into the ground.

Example IV.—Quay Wall Construction.

This is a typical example of a Hennebique quay wall, constructed of piles in combination with their beams and floor slabs, somewhat similar to the one at Southampton Docks. It consists of a facing row of sheet piles, marked A (Fig. 21), divided into bays of 7 feet from centre to centre by a modified form of sheet pile called a counter, driven with its shorter side in the same plane as the external face of the others; behind these also, at 7-feet centres, are three rows of square or bearing piles (B Fig. 21), supporting and intimately connected to the beams and the superimposed reinforced concrete platform or decking. Upon the sheet piling is fixed the superstructure or curtain (C) of the quay, stiffened at every 7 feet by reinforced concrete angle-pieces or buttresses (D); these in their turn being built into the curtain at the front, and the decking beneath as far as the first row of bearing piles; the whole being surmounted by a coping (E) composed of the same materials. Elm fenders (F) are attached to the face of the quay wall, by iron bolts fixed through the sheet piling and curtain. On the exterior face of the wall, at the junction of the sheet piles, curtain and decking, is formed a continuous projecting waling (G), which not only gives additional horizontal strength but adds to the finished appearance of the quay itself.

The percentage of the metal to that of the concrete for the reinforcement is 3 for the sheet and 4 for the bearing piles. The live load of about 3½ tons per square yard is practically carried on the decking, the buttresses bracing the curtain against the impact of vessels, transmitting the pressure on to the decking, where it is distributed over a large area; while the fenders protect the face of the concrete from any damage likely to accrue from actual contact with the ships' hulls. In the calculations for structures of this kind the materials are assumed to be homogeneous, and treated as a retaining wall. It is instructive to compare the dimensions, mass, etc., of this reinforced concrete wall with a masonry one of the same load (see Fig. 21). Such a wall could be constructed at a cost of about 22*l*. per lineal foot, being about half the cost of a masonry one.

Finally, the Author desires to record his thanks to some of the various patentees and constructors for particulars concerning their respective piles, and also to the different standard works for a good deal of information connected with the subject.

DISCUSSION.

Mr. J. Lemon: I should like to move a vote of thanks to the Authors of the papers, and to our President for reading them in their absence. I have had some experience in the use of what is called armoured or reinforced concrete, or, as I call it, ferro-concrete. I superintended the construction of some large coal hoppers at Portsmouth, which were designed by M. Mouchel on the Hennebique system. They are supported entirely on piles. The experience I gained in that way was this, that it takes rather more time in construction, and it certainly is not cheaper than other modes of construction; but notwithstanding that, I am of opinion that this ferro-concrete has come to stay. But I would like to throw out a word of warning, following on the lines of Mr. Palmer, that engineers ought to be very careful in using this reinforced concrete. A very great deal depends upon the way in which the concrete is made and on the materials, and I am afraid, with many different systems in the market, there will be a tendency on the part of some inventors to put up very light structures which may come to grief. I agree with Mr. Palmer as to not giving any formulæ. I should not like to lay down any formulæ, though I have given the subject a good deal of attention. One of the advantages of this system of construction is that you can get a large floor, covering a good area, at the minimum depth of floor. You can construct such a floor 6 inches thick,—I have seen them 5 inches thick—which is a great gain in the height of the building. A large building has been erected close to my office, and I have noticed that there is considerable delay in erection. They have to use such a large quantity of boards that it interferes with the process. A new system has been patented—or, at any rate, protected—by which it is proposed to make concrete sheeting, so as to save time in the ordinary construction. I am told that in that building the cost of the boarding or sheeting was about 25 per cent. of the whole cost. If so, there is a very large item of saving. As you know, concrete piling has been used at Southampton at the cold storage, the docks, and other places. My experience is that concrete piles are certainly things to be used in such cases. They have great advantages in many respects. For instance, the worm does not attack them in any way whatever, and they can be easily driven. It is really marvellous to see the amount of hammering that a concrete pile will stand,—I was surprised when I saw the first pile driven. They hammered away with a heavy ram, and it did not have the slightest effect in the disintegration or breaking up of the pile. I believe that concrete piles will entirely supersede wood piles.

Mr. E. B. Martin: I should like to second the vote of thanks to the Authors of the papers. I had beams made of concrete and reinforced by expanded metal in various ways, on which I made a number of experiments in order to get some idea of how they would act under a load. The beams were all of uniform size, 6 feet 6 inches long, 10 inches wide, and 6 inches deep. They were composed of concrete in the following proportions: broken brick 3, sand 1, cement 1. Specimens were tested with a central load applied by means of a ram with supports 5 feet apart. No. 1 beam contained no reinforcement. No. 2 beam contained a reinforcement consisting of a sheet of expanded metal laid parallel to the tension surface of the beam and about $\frac{1}{2}$ inch distant therefrom. No. 3 beam contained a reinforcement of a similar sheet of expanded metal bent up from the centre towards the compression surface of the beam. No. 4 beam contained a combination of Nos. 2 and 3; the expanded metal consisted of what is known as size No. 10, with 3-inch mesh, $\frac{1}{4}$-inch by $\frac{3}{16}$-inch strands. The reinforcement amounted in specimens Nos. 2 and 3 to 0·5 per cent., and in specimen No. 4 to 1 per cent. The results were as follows: No. 1 broke at 7·4 cwt.; of Nos. 2, 3 and 4 (of which two specimens were made) No. 2 broke at 32·4 cwt. each; No. 3, one specimen broke at 44·3 cwt. and the other at 43·5 cwt.; No. 4, one specimen broke at 59·1 cwt. and the other at 66·5 cwt. It will be seen that the relative strength of these beams, taking the one without reinforcement as 1, was for specimen No. 2, 4·4; specimen No. 3, 6·0 and 5·9; and for specimen No. 4, 8·0 and 9·0. The results of the experiments tend to show that the 1 per cent. of reinforcement in specimen 4 was beyond the percentage of reinforcement that can be economically used. I am of opinion that concrete made with different matrices necessitates different forms of reinforcement, thus in the South of England, where chiefly gravel is used for concrete, a smaller meshed reinforcement could be used than in the North where we have to rely upon broken stone or brick. Professor Goodman of the Leeds University has interested himself in this subject, and made many experiments using different forms of reinforcement. Among others he has tried circular rods, but finds that they do not provide a sufficient key and are apt to tear out under a load. He suggested to me quite recently that disused colliery ropes, of which one is able to find many in the North of England, would provide an excellent key. This point of assuring to the reinforcement a good key with the concrete is, I think, most important.

Mr. J. **Lemon**: In the North of England where you cannot use gravel, would you not use sand for the broken brick?

Mr. **Martin**: Yes.

Mr. **Smillie**: Might I ask how old these beams were?

Mr. **Martin**: Thirty-seven and thirty-nine days.

Mr. A. D. **Greatorex**: I should like to call attention to two very important papers which I think every member of this Association should read in connection with these very valuable papers. I refer to a paper by Mr. W. Dunn on "The Construction and Strength of Reinforced Concrete Columns," and by M. L. G. Mouchel, on "Monolithic Constructions in Hennebique's Ferro-Concrete."* These papers give a description of the system and the tests carried out; they also give the Hennebique formulæ and diagrams showing safe loads, and if followed out, you can carefully test the calculations of the specialists in this class of work, and they will be found extremely useful. I have lately had a design prepared for a small canal bridge in this class of work, and as regards the estimated cost as against brickwork, there was not very much difference between the two. I also went into the question with reference to a sewer. I have had a lot of trouble with a brick sewer, which was 2 feet 3 inches in diameter, and which had gone down through mining operations 7 or 8 feet. The sewer had been working satisfactorily until the day it collapsed, owing to what is known as "crowning in," a portion of the sewer disappearing altogether. A suggestion came from Mr. Eayrs as to whether the sewer could not be constructed in ferro-concrete, 6 feet by 2 feet 3 inches, the idea being that the sewer could be gone through from time to time to see if it was sinking, and whether it was necessary to have it raised. I went into the matter carefully and had a design got out and the cost estimated. It was to be about 4 inches thick. It came out more expensive than the cast-iron pipe we are going to relay it in. I was assured that the sewer could be lifted if it went down 3 or 4 feet, and that they could make good any cracks, the same as the iron pipes. It has cost more than 1000*l.* to construct 400 yards of sewer. When I get the opportunity I intend to carry out some work in this material.

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* *Royal Institute of British Architects*, vol. xii. third series. Price 1s.

Mr. H. K. G. Bamber: I should also like to congratulate the Authors of the two papers upon having brought forward such an important matter at a meeting like this. I am not an engineer, but it seems to me that at this moment the municipal engineer is seeking information as to ferro-concrete. It has been a subject dealt with for years in America and Western Europe. Unfortunately engineers in this country have not seen fit to take up this class of work, and only now seem to be turning their attention to it. There is a publication in America entitled "Cement," which contains a vast amount of information about ferro-concrete. It is a paper full of information, tables, etc., with reference to ferro-concrete. Indeed, you will find in it a vast amount of information which would take some years to find out by experiment, and from what we have heard the municipal engineer has no time to make experiments as such, so that unless someone gives him the information, he is left to make experiments in works under his control. It gives me the greatest pleasure to see, in this paper, such a strong opinion given, not from the manufacturer of cement, but from the user of it. It is clear that those who have gone into this work have realised that nothing but the very finest cement is of use in this particular construction. First, it must be fine ground; it must be sound; and above all, it must be slow-setting.

Mr. A. C. **James**: I should be obliged if Mr. Palmer would kindly give further information as to the construction of sewers in ferro-concrete. In my district, the subsoil is practically soft soap, and the saving in weight which would result from the use of ferro-concrete is a matter of importance. I recently had to design a swimming bath to be built upon this soil, and with a view to find the cost if built with reinforced concrete, asked for a price to be given. The price asked was 15 per cent. higher than the ordinary work. It has been the practice to reinforce the work with old steel rails. We have done that at the sewage works. We had tanks there in which the sides have completely broken through. I had to construct some bacteria beds of double the weight on adjoining land and reinforced the walls with steel rails, and there is no sign of settlement whatever. Near to my district at Purfleet, almost adjoining the Karri and Jarrah works, a jetty has been erected on piles of reinforced concrete by the Hennebique system. They were constructed on the method described by Mr. Galbraith. The heads of a good many of the piles were shattered by the blow in driving, but they were comparatively easily repaired; it was only where the breakage took place in the water that any difficulty occurred. I was struck by the quantity of carpentry work required. I should not like to say how many thousand feet of timber the contractor's engineer told me they had to destroy. The jetty is only 7 inches thick, and carries some heavy cranes. The platforms of West Ham station on the London and Tilbury line are built of concrete reinforced with expanded metal. It is 8 feet span, only 5 inches thick. The station adjoins one of the Metropolitan Football grounds, so large crowds assemble there. It has now been opened five years, and therefore has been well tested.

Mr. J. T. **Eayrs**: I quite agree with the remarks of Mr. Lemon that this armoured or reinforced concrete has come to stay. But I think very great care should be used by engineers in the designing of structures where this form of construction is adopted, and more particularly as regards the quality of the materials which are used in making up the concrete. It is a most difficult thing for an engineer, unless he is constantly on the job, to have his materials properly selected, and if any inferior material, or any material not properly mixed, is used there is no doubt there will be a serious collapse, which will no doubt deter others from using this material. I do not agree with Mr. Lemon as to the cost, because, I believe, in a good many instances ferro-concrete will be found considerably cheaper than the ordinary methods of construction.

Mr. J. Lemon: Not in all cases.

Mr. J. T. Eayrs: There are a great many cases where it would prove a great saving, viz. in the construction of tanks, where one has to put 3-feet, 4-feet, or 5-feet walls, the saving by the use of armoured concrete would be very great. In the construction of tanks a large amount would be saved in the quantity of excavation where you could get walls 4 inches, 5 inches, or 6 inches thick instead of 3 feet, 4 feet, or 5 feet thick. This would make a considerable difference in the cost of construction of tanks. Mr. Palmer, in the last paragraph of his paper, says he has purposely refrained from introducing into the paper any of the many formulæ used in working out the stresses in reinforced designs. I disagree with my friend, Mr. Lemon, on that point. I think it would be as well to introduce all the formulæ upon which the designs are based, because without them we are unable to satisfy ourselves as to the merits of any system placed before us. The patentees are very chary of giving the formulæ upon which their construction is based. Whenever one has to go to the Local Government Board, or to advise an authority, you must have reason for your faith, and you must be conversant with, and fully appreciate, the formulæ upon which all the calculations of stresses are based. With municipal engineers particularly, you have to go to the Local Government Board to borrow money, in which case you want to be able to answer any questions that may be put to you by the inspector in support of the scheme put forward. I have had some conversation with the engineering staff of the Local Government Board, and I have come to the conclusion that the Board is not very favourable to reinforced concrete at present. Indeed, they appear to be very chary of its use, and will require a good deal of information before sanctioning the erection of any structure of first class importance. In fact, I know some of the members of the staff are entirely against it. I asked whether they took any notice of the reinforcing at all, and whether you had to make the structure sufficiently stable as if it were without the reinforcing material. Though I could not get anything reliable or definite on the point, I understood that the Local Government Board satisfied themselves as to the stability of the work without any reinforcing. If that is the case, there would be no saving at all, as you would have your walls stable without the reinforcement. I have had the pleasure of seeing some of these reinforced concrete structures. One instance is the water-tower at Bournemouth. I was exceedingly struck with its very light construction. Although the tank is about 15 feet deep, it is perfectly watertight, and the thickness of the sides is 4 inches at the top and 5 inches at the bottom. A few years ago one dared not have suggested such a thing, but now it is an actual fact.

Mr. Blair: Are there any cross-ties in that?

Mr. Eayrs: No. I have also seen Weaver's grain silos at Swansea. There the partitions in the grain silos are 60 feet to 80 feet high, and the walls are 4 inches thick at the top and 5 inches thick at the bottom. And we all know that to contain 60 feet to 80 feet of grain, ordinary walls would have to be of enormous thickness. But these 4 inches to 5 inches are considered sufficient, and there is not a crack in the building. I believe that building is also constructed on concrete piles.

The President: I will see that the Authors of the papers are informed of the votes of thanks which have been given them. I have carried out a good deal of moulded concrete work, but very little ferro-concrete. I have got over the trouble of the waste of timber by only using moulded work where there is a lot of repetition, and then using iron moulds. I have some work now where I am building a parapet, and that is coming out at a very low price indeed.

Communicated Reply.

Mr. Palmer: Mr. President, allow me to thank you for having the kindness to read my paper on Reinforced Concrete. I was unavoidably absent from a meeting at which I should very much like to have been present; and I am glad to see that the subject was one which was interesting to the Members of the Association, and productive of discussion. I think there is very little for me to reply to; and I am extremely pleased to see that the Members of the Association are following up the use of reinforced concrete by associating themselves with the Royal Institute of British Architects.

With regard to the remarks made by Mr. James as to the construction of sewers in ferro-concrete, this branch of the subject is one which requires very careful consideration, and in my opinion it is not prudent or feasible to use armoured concrete except for comparatively large sewers or conduits. There are distinct and very appreciable advantages to be gained by the use of this material in bad ground for a structure of considerable size. Many examples of large sewers are to be found built in armoured concrete, both in Germany and America, either constructed entirely in concrete or lined with brickwork. The armouring for structures of this kind usually consists of either a network of small steel rods or stouter steel rods used transversely to the section of the sewer. Although it is usual for these structures to be built in monolithic sections, as a rule not exceeding 20 feet in length, there are known cases where as long a length as 50 feet has been put in at one operation. In constructing sewers in ferro-concrete, the necessity of having the concrete fine, made of the very best materials, and packed in in a sufficiently wet state to ensure homogeneity, must be borne in mind; and the inside surface must of course be rendered after the centres have been removed, if not lined with brickwork. Expanded metal makes a very suitable armouring for sewer work. Armoured concrete sewers of small dimensions, i.e. up to 3 feet or 4 feet in diameter, are cast in special plants, and are usually manufactured by some patent process.

There is no doubt that armoured concrete will, by degrees, be used very largely for sewer construction in this country, and where good materials can be obtained cheaply its cost will be considerably less than a brick-constructed sewer. But here again the use of this material must largely depend on local conditions and circumstances, and for its success should be carried out by men thoroughly accustomed to all kinds of good concrete work. The strength of the material depends so much on the proper manipulation and placing of the concrete and armouring, that it is requisite that the work should not be entrusted to ordinary labourers but to skilled concrete workers.

ADAPTATION OF HIGHWAYS FOR MODERN TRAFFIC.

By C. H. COOPER, Wimbledon.

It must be apparent to the most casual observer that many of the existing highways of this country are sadly in need of improvement in order to adapt them for rapid traffic, such as has been introduced with self-propelled vehicles. The fact that some of the existing carriageways have remained in their present condition as a menace to life and limb for so many years reflects great discredit on highway authorities.

Many authorities allow buildings to be brought forward in such a manner that ultimately large sums of money have to be expended in order to widen highways which must eventually form arterial thoroughfares. The Author knows of many cases in and about the Metropolis, where, within the last thirty years, owners offered land to highway authorities, either without payment or for a nominal sum for the purpose of widening highways, provided the authorities did the paving; but the so-called economist of those days had not the nerve to undertake such paving, the consequence being that now buildings have been erected these widenings become matters of necessity, and hundreds of thousands have to be expended where hundreds would have sufficed some few years since.

By-laws, and so far as the Author is aware, local Acts, make no provision for the rounding of corners at the intersection of roads, even in the case where such roads are being laid out.

The Author has been much struck with the great difficulty experienced in getting local authorities to appreciate the necessity of wide highways and the rounding off of corners, and he has been met with such arguments as that Ratcliff Highway, which is only 30 feet wide, carries more traffic than any road in his district, and why therefore should he insist on a wider road—and this not from an ordinary member of a council, but from an eminent member of the engineering profession.

It would be well if some provision were in force to compel highway authorities to have all new streets so laid out that every portion of the carriageway is visible from every other part of such carriageway, which is within a distance of at least 100 feet, and that at the junction of any two carriageways the same rule is observed as if they formed the same street. The reason of this provision is, that vehicles approaching should see each other at as early a period as possible, so as to give every opportunity of avoiding collision.

Steep inclines form a great source of danger for all forms of wheel traffic, more especially when roads meet on inclines or at, or near, their lower termination. The Author knows of nothing that shows the absurdity of having a uniform rate of speed allowed for vehicles, more than the case of steep inclines, especially when it is remembered that on many of these inclines not a single week passes without accidents, which if not accompanied by loss of life or personal injury, results in considerable damage to rolling stock and fences, which shows that it has been due more to good luck than otherwise that personal injury has not accrued. Authorities should therefore endeavour as far as possible to have streets laid out so as to reduce inclines, and where roads intersect to round off corners next the higher portion of the incline to as great an extent as possible.

SURFACE.

The surface of carriageways is a matter which requires considerable attention, not only to carry horse traffic in comfort, but more especially to ensure safety and comfort to cyclists and motorists. The surface should therefore be as even as possible, and although all carriageways should be properly arched, there should be no excessive arching such as would lead to the centre of gravity of vehicles being placed dangerously near the outer wheel. No gully gratings should be allowed in the carriageways, but gullies should be placed beneath the paths, with a proper weir formed in the kerb to take the water on to such grating, this leads to the necessity for provision being made to prevent mains being placed beneath the paths in such positions as to interfere with that suggested for the gulley-pans.

Many persons look on motors with pneumatic tires as causing considerable damage to highways. This is no doubt the cause where carriageways are badly constructed in the first instance, or are badly maintained; but the Author knows of no form of traffic which causes less damage to carriageways, provided the surface is properly laid and a proper state of moisture maintained. This will be seen on a main road taking a large quantity of motor traffic on a spring or autumn morning when the carriageway holds just sufficient water; a beautifully smooth surface will result from the constant rub of the pneumatic tires; a very large amount of tonnage is thus carried with a minimum amount of damage to the carriageway.

There is no doubt that when railways became the great carriers of the country the question of our highways became a matter of secondary consideration; in fact, in too many cases they were neglected to an extent that must have damaged many interests. This state of affairs is rapidly changing, as our carriageways have, with the introduction of self-propelled vehicles, become a great means of conveying the wealthier portion of the pleasure seekers. At the same time the introduction of heavy motor traffic is being instituted for the carrying of goods, a class of traffic which must of necessity increase enormously. Local authorities, if they wish to remain highway authorities, must, therefore, make up their minds that the ordinary country road, which in years gone by was never subjected to a load exceeding 2½ to 3 tons, will in the near future be subjected to loads of at least ten times this amount, and that any attempt to prevent these loads traversing their roads at seasons when injury is likely to be caused cannot be maintained. The only step for such authorities to take is to form their highways in such a manner as that at all seasons they are capable of bearing heavy traffic, and, above all, to see that all new streets and roads are so laid out that they will carry heavy traffic at all seasons.

This work may appear to involve at first sight a large capital outlay, but the Author can only state that in his own district, in which he is happy to say there are now very few roads without proper foundations, the cost of maintenance of roads properly formed is far less than that of roads without good foundation, and that the difference in cost of maintenance per mile more than compensates for the cost incurred in properly forming the highways in question.

There are obstructions which should be avoided as far as possible, viz. the placing of lamp-posts and sign-boards close to the carriageway. These should be placed in such positions as not to interefere with the use of the whole of the carriageway, which they do if placed in such position as to engage overhanging loads.

FOOTWAYS AND BRIDLE-PATHS.

Although the title of this paper may not entitle the writer, he cannot conclude a paper on highways without referring to the neglected state of footways and bridle-paths throughout the country. Now that our carriageways are being converted more or less into engine tracks, the solitude of these paths forms a most pleasing contrast to the danger and flurry to which our highways are subjected, and the Author thinks it is a matter which reflects very severely on highway authorities that in many cases they take no steps whatever to prevent these footways and bridle-paths being closed—viz., Ermyn Street, the Roman road crossing Epsom Downs and Mickleham, Surrey. Others are so overgrown with trees as to be perfectly useless. The Author knows of many in which one would be above his knees in mud were he to attempt to traverse them. Whilst highway authorities have of necessity to lay out money to accommodate the pleasure-seeking motorist and cyclist, the Author considers that the equally deserving individual who is still satisfied with the means of locomotion that the gods have allotted him has quite as strong claims on the rates expended on highways as the individual who can afford 1000*l.* for a motor. But whereas hundreds of thousands of pounds are laid out to provide for the comfort of the latter, not one penny piece, so far as footways and bridle-paths are concerned, is laid out for the former. There is no doubt that this is to a large measure due to the desire on the part of landowners to attempt to close, as they do in many instances, footways and bridle-paths.

DISCUSSION.

The PRESIDENT: Mr. Cooper suggests that proper powers ought to be given to local authorities to insist on the rounding off of corners at the intersections of roads. I quite agree with him. At the same time I think surveyors have to be careful as to the amount of such curving they give to the carriageway. If such junctions are made too easy it will permit of motor cars and other vehicles rushing along at too great a speed. I would give the extra space to the footpath so as to be a protection to foot passengers at the same time facilitating vehicular traffic by enabling vision for greater distances into joining streets. At one time I put up mirrors in Norwich at the corner of roads. They gave great satisfaction but the small boys broke them up to such an extent that we had to give up their use. As to constructing gulleys in the footpaths, I have had to do that in Norwich, not for the reason given by Mr. Cooper, but because of the narrowness of the streets, and in some cases have been forced to put them near the boundary of walls and houses. The owners are responsible for paths across fields, and if they do not maintain them, and the public authorities do not compel them to maintain them, the public have an absolute right to divert where the paths are impassable. If the public will do that the owners will often do the work of repair. I know there are difficulties in getting owners to effect repairs to field-paths, and in some cases it is more economical to do it yourselves. But the public have powers in this matter.

Mr. A. T. Davis: I have pleasure in proposing a vote of thanks to Mr. Cooper for his paper. I agree with the President that in the matter of rounding off corners it is better to round off the building line, rather than the kerb line of the footpath. That tends to the safety of the public. It enables drivers of vehicles to see approaching vehicles and it compels them to slow down at corners as they ought to do. As to curves I was inspecting some a few days ago in my county of Shropshire at points where we were proposing to put up motor notices. I measured with my divisional surveyor the distance at which we could see each other, and I found we could see each other in one case at 45 yards distance, so I decided not to erect a warning notice there. I notice that Mr. Cooper puts the minimum distance at which drivers ought to be able to see each other at 100 feet or 33 yards. I think, however, that is little enough. It is far better in the laying out of new roads and streets to work on the principle of prevention being better than cure, and make the curves so that drivers can see each other rather than to have to put up notices advising them to observe caution. As to wide roads I was in London recently and was driving along Kingsway, the new road from the Strand to Holborn, and the gentleman I was with called attention to the width of that road—what he called the absurd width of the road. He said to me "it is absolutely impossible for us to carry on trade in so wide a road, as it takes so much time and trouble for people to get from one side of the road to the other. We don't want people to walk along on one side of the road only, but to cross over from one side to the other, and give us all a chance." That shows there is another side to this question of wide roads. Those who are tradesmen regard this matter from the aspect of the effect upon their own pockets, as my friend in London the other day looked at it.

Mr. H. T. **Wakelam**: I should like to confirm the statement made by Mr. Cooper, as to the absolute necessity for wide roads in the neighbourhood of London. A fortnight or three weeks ago, it was my duty to submit to a special committee schemes for widening the trunk roads out of London from 80 to 100 feet. To do this would, of course necessitate a very large expenditure. I feel as Mr. Cooper feels, that these roads must either to-day or at some future date be widened for the ever-increasing traffic. The main road that we have passing through Brentford to-day is really a blot on the suburbs of London. If that road could only be widened at a moderate cost, it would be a most useful work. My estimated cost of the widening, however, is something like 450,000*l.* If the trunk roads out of London are to be widened, it means an exchequer grant, because certainly the county of Middlesex cannot bear the whole expense. As to rounding off corners, I agree that it is not a wise thing to have too easy a curve at the corner. If you have the buildings rounded off, it is much better and safer for traffic. Mr. Cooper will have the same experience in this respect as I have in Middlesex. With regard to signboards this matter was thoroughly discussed at the annual meeting of the County Surveyors' Society in London, and much good has been done in the county of Middlesex, where we had returns sent in by the urban and rural authorities for something like 1500 signboards and symbols which were wanted under the motor car regulations for dangerous places, corners, and cross-roads in the county, and we are now erecting something like 999, which shows the necessity for improving the roads and curves in Middlesex. The village of

Colnbrook on the Bath road is an actual death trap for people who get in the way of fast motor traffic. If legislation can be obtained to meet such difficulties in the counties around London, something to the advantage of the vast population concerned will have been brought about. In connection with the extremely large scheme of light railways and tramways I am now carrying out in the county of Middlesex for the county council, all the roads over which the railways and tramways are being taken are being widened to a minimum width of 50 feet. At present I have about 35 track miles already laid, and working, the routes of which have all been widened to 50 feet at a very considerable expense. The acquisitions of lands, road widenings and works (apart from administration, trackwork, etc.) have cost about 30,000*l.* per mile. From this it will be at once seen what an enormous expense it would entail to widen the trunk roads to 80 or 100 feet, on most of which roads whole properties would have to be purchased. We have already in numerous cases set back frontage fences and forecourts which, necessarily, are not so costly as whole properties would be. In connection with the Middlesex county scheme, I have still about 60 to 70 miles of trackwork and widenings to carry out—plans for which are practically all ready.

Mr. C. H. Cooper, in reply, said: I am very pleased that you have thought fit to accept this little paper, which was written simply to bring certain important points which appear to me had been before you. As regards the rounding of corners I have been rather surprised to hear what the President and Mr. Wakelam have said on that point. The reason for curving is to allow the drivers of two vehicles coming in different directions to see each other at as great a distance as possible. To allow sharp corners to be made is one of the greatest possible mistakes. In the case of tramways you insist upon property being purchased for the putting in of proper curves, and why should you not be equally particular in the case of ordinary vehicular traffic. As to Mr. Davis's remarks on the possibility of too wide roads, I am afraid we are not likely to get many of these roads. I know a road in a district adjoining my own which will be a main thoroughfare out of London, and they are allowing the buildings to be erected so that the road cannot be more than 40 feet in width. Let me advise those who advocate narrow roads to go to Brentford and see what is going on there.

It is an absolute fact that vehicles have to draw up on the footpaths to unload. The widening of the Harrow road and other roads under Mr. Wakelam are works which will be of great value.

The **President**: There was no suggestion that the corners should not be rounded off; only don't put all the rounding into the carriageway; because if you do you will encourage fast vehicular traffic, and make matters worse than they are now.

TRAMWAY PERMANENT WAY MATERIALS AND CONSTRUCTION.

BY JOSEPH OWEN, COLCHESTER.

WITH so much matter previously written, no doubt some apology is necessary in introducing another paper on the above subject, but the Author trusts that he may present something of interest to the younger Members of the Association, craving at the same time the indulgence of those who have already an extensive acquaintance with the subject in question.

MATERIALS.

Rails and Fish-Plates.—The standard specification and sections of tramway rails and fish-plates issued by the Engineering Standards Committee are admirably suited to meet the varying conditions of traffic in this country, and their adoption enables the manufacturer to keep in stock a quantity of each kind of rail, while saving the cost of providing a new set of rolls for each individual order. On the other hand, when an article is brought up to standard, there is a tendency to suppose that finality has been reached, thus checking initiative.

Rails 60 feet in length are now nearly universally used, as it has been found that they are but little more awkward to handle than those of 45 feet. Turning can be reduced to a minimum, by arranging that the heads of each pair of rails are on opposite sides when loading up the lorries.

The fewer number of joints more than compensates for any small increased difficulty in handling.

In the earlier days of electric traction the carbon specified in many cases was as low as 0·35 per cent., but with heavy traffic and steep gradients this soon proved much too low. An average of 0·50 per cent. has been proved a happy medium, being sufficiently low to avoid signs of fracture, even when crowed to a curve of 30 feet radius, and sufficiently high to obtain a chemical composition producing a tough durable rail.

For the British standard section No. 2, the weight of fish-plates is given as 49½ lb. per pair, but this being the weight before the holes are cut is somewhat misleading. The actual weight as supplied is 46¾ lb. per pair—a difference of about 6 per cent., sufficient to make a large error where an extensive contract is involved.

To avoid the possibility of the fish-bolts working loose by vibration, they should be fitted with a lock-nut, of the type manufactured by Messrs. Ibbotson Bros., Sheffield.

Special Work.—Perhaps in no other department of tramway construction have the British manufacturers made such improvements as in the case of points and crossings, etc. A comparison of the old, short cast-steel point with the 13 feet 6 inches point now used will best demonstrate this. The latter can now be obtained either as a casting composed entirely of manganese steel, or of the type known as "iron-bound," which consists of pieces of ordinary rolled rail, the portion where the wear is greatest being fitted with a renewable plate of manganese steel, which is keyed down and finally run in with spelter; the various portions being consolidated with a strong binding of cast iron.

Iron-bound crossings are constructed in a similar manner to the above. Automatic and movable points are also fitted with tongues of manganese steel.

The great advantage of using iron-bound points and crossings is, that uneven wear at the joint, due to difference in material, is greatly reduced, as the insert plate is splayed back and tightly fitted.

The extended legs can also be crowed a little, if necessary. A small percentage of the insert plates become loose, but this can be remedied by directing the flame of a blow-pipe on the spelter, taking out the plate and running in a fresh quantity of the cementing material; or the plate may be secured by driving in small hard steel wedges at opposite corners. When used, the blowpipe should be carefully directed, or there is a danger of cracking the casting.

A crossing with a loose insert plate, on being examined, was found to have the binding cracked, probably owing to its position on the roll of a hill, and being more rigid than an equal length of rail.

Figs. 1 and 2, on Drawing No. 1, show a side and a diamond turn-out respectively, and at the end of the paper will be found some of the calculations necessary for their design.

The points are 13 feet 6 inches long, with a straight run in on the left-hand side, and curved to 200 feet radius on the right. This throws the crossing a little out of centre, but allows the car to recover from any jolting consequent on entering the points before coming on the curves; for the same reason it is necessary to have a tongue of greater length than the wheel base.

Where a loop is situated on a hill it is better to arrange for a side turn-out to be taken by the "up" car, leaving a straight run through for the "down" car, to avoid a probable accident in the case of a runaway passing through the loop.

For any kind of special work, two open points for one track should be avoided, much smoother running being ensured by using an open and a movable point together.

The movable point should also be on the side to which the curve runs. Thus, if the curve is to the right, the right-hand point should be movable or automatic, and the left-hand point open; and *vice versâ* if curved to the left. With this arrangement, the back of the car-wheel flange bears on the tongue, but when the movable point is on the wrong side there is a great tendency for the wheel flange to mount the tongue.

Fig. 1 on Drawing No. 2 shows a complicated arrangement of points and crossings, sometimes adopted for car depôt entrance curves. An arrangement just as efficient and much more economical is shown in Fig. 2.

Entrance curves should terminate before the pit is reached.

Fig. 1 on Drawing No. 3 shows the cross section of a depôt pit, the rail being secured to a creosoted oak sill by dogs and coach screws, and kept to gauge by screwed $\frac{7}{8}$-inch round iron tie-bars between the pits.

Joints.—The life of the rail is only that of the joint. To provide support, various methods have been adopted.

The joint plate shown in Fig. 2 has been used in various places with unvarying success, and is a proved cure for "knocking" joints in old track. Its principle is that of the parallel plates in a level. It consists of a metal bed-plate resting on the concrete, a steel "supporting" plate in which two holes are screwed, and of two hardened steel bolts, which, on being screwed home through the holes provided in the supporting plate, engage with the bed-plate, and thereby lift and support the joint to any required position. Any subsequent depression, due to the rolling load or any other cause, can be readily adjusted by the use of a box-spanner without any disturbance of the paving. In new track work, it is claimed by the inventor to entirely obviate the necessity of expensive steel fish-plates, their primary function, that of support, having entirely ceased. In place of fish-plates, what are really two large cast-iron washers are substituted, being held from lateral movement by two ordinary tie-bars; shorter electric bonds may also be used. In Manchester, where the joint support was first tested, several "knocking" joints were remedied, and are now in a perfect condition after twelve months' test with a one minute service, which is equal to a five years' test with a five minutes' service.

Too much attention, in the past, has been paid to railway practice, although the conditions are totally dissimilar. In no other case, has this proved so expensive as with the custom of leaving a space for expansion, and the joint unsupported. In the opinion of the Author a joint cannot be too rigid, and the nearer a continuous rail is approached the smoother will be the running. The joint plate that allows for a cushion effect is a certain failure, as the depression becomes greater after a time, allowing the rail to swing. No room for expansion need be made in this country. Each rail should be hammered on the end to ensure the tightness of the previous joint. Many joints which have been left wide could be greatly improved by inserting a thin section of the rail. This would be held tightly in place by the fish-plates. Others are so bad that only by cutting out the joint and inserting a short piece of rail, varying in length according to the wear on either side of the joint, could any improvement be effected.

It was observed that a certain length of track was badly out of alignment, due to being exposed to the sun previous to paving and concreting. The rivets were therefore cut out, the fish-plates taken away from one joint on each rail, and the rail ends allowed to slide past each other. In a short time, there was an expansion of 4 inches showing. The track was then concreted to within a short distance on either side of the released joint, which was afterwards fished up and concreted late in the afternoon. Once the flange was embedded in concrete, it was found that, although the rest of the rail was exposed previous to paving, the expansion was negligible, being only apparent by a fine crack in the concrete over the flange at a point where there was a sharp curve. A slight amount of "creeping" will be encountered, mostly on the hills, but can be neutralised by placing cross plates in the middle of each rail.

Tie-Bars.—But little saving is effected by using tie-bars notched at one end and screwed at the other, and they are not so efficient as those screwed at each end. When finally easing the track in line with bars, the notched ends slip, thus altering the gauge. It should be insisted that all tie-bars comply with a certain standard of strength; those supplied by a certain maker were so weak, that during the night, owing to contraction of the rails at a curve, the tie-bars buckled, altering the gauge as much as 10 inches.

Bonds.—In choosing the type of bond, preference should be given to one which can be re-used in case of repairs, etc.

Plastic bonds, inserted between the fish-plate and web, have been proved practically a failure, losing a large percentage of conductibility after a short time, besides requiring careful handling owing to their poisonous composition. Cross bonds should be placed at intervals of 50 yards on the straight track, and long bonds over the points and crossings in addition to those provided for an ordinary joint.

Drain Rails and Boxes.—There is no advantage in using drain rails in preference to boxes, and their use merely increases the number of joints, and causes additional wear due to difference in material. Trapped drain boxes are extensively used, but seem a little unnecessary where the sewers are ventilated by means of perforated man-hole covers; a slot cut in the bottom of the groove discharging over a square box dished down to the outlet would carry off the water quicker, without the same liability to become choked with sand, etc.

SETTING OUT.

Having prepared an accurate plan of the route, the track may be plotted on, and the radii of the various curves found. Much unnecessary time is ordinarily wasted by setting out the whole of the centre lines by the theodolite. The following rapid method of setting out ordinary curves has been used extensively by the Author on a recent contract.

The ends of the curve are tied in from some defined points on the street line, and the versed sine is obtained from the well-known formula:—

$$V = R - \sqrt{R^2 - (\tfrac{1}{2}C)^2} \text{ where } R = \text{radius and } C = \text{chord.}$$

Referring to the exaggerated sketch in Fig. 3, Drawing No. 3, having found versed sine BD, the offset EF may be set off $\frac{1}{4}$ BD; and similarly GH = $\frac{1}{4}$ EF.

This method may be extended until the poles touch each other if desired.

To take a simple case. With a radius of 2504 feet and chord 400 feet, the versed sine BD = 8 feet, EF = 2 feet, and GH and JK = 6 inches. The maximum error is at E, where the offset is actually 1·998 feet, or an error of only $\frac{1}{40}$ of an inch. This error would, of course, be greater on sharper curves, but the method may be used on all curves where the chord is not greater than half the radius. A, B and C being actual points on the curve, errors are minimised.

The above method can, of course, be utilised for setting out kerbs, etc., where the radius is not known, by assuming an offset at the centre and proceeding as before. Where the chord is long, the poles may be sighted in straight line by the theodolite, or other telescopic instrument.

Portions of straight track between two curves in the same direction should be avoided, or a very unsightly appearance is presented, the termination of the curve being very apparent.

A flat curve between the two sharper ones will greatly improve the appearance of the line in such a case. Between reverse curves, however, it is an advantage to have a short portion of straight, otherwise the curves appear so distorted on the ground as to be meeting at a point instead of tangentially.

If several ranging rods are put in, any apparent deviation from the true line can be adjusted to the eye, saving a great amount of easing of the rails when laid, to take out any such abrupt change of line.

For double junction and other special work the system of spiralising the curves is now generally adopted. A central circular curve is decided upon, from the termination of which the line is eased into the straight by a succession of short curves each of larger radius than the last.

For example. A curve with a central radius of 39 feet is gradually diminished to one of 429 feet before running tangentially into the straight at a point 27 feet 6 inches from the termination of the central curve. By reference to tables, the offsets and lengths can be ascertained to suit various central radii.

Where the central radius is not thereby made too small, one of the best methods of negotiating a corner is by means of a parabolic curve, in which the radii are varied from centre to termination at the straight, thus avoiding the appearance of a "knuckle" at the latter point, which is always so apparent when a curve of uniform radius is set out.

Curves are not unknown on which the Board of Trade have refused to allow two cars at one time, due to the fact that insufficient allowance has been made for the overhang of the inner car during progress round the curve. In Table No. 1 is given, to the nearest ¼ of an inch, the necessary allowance for the overhang of ordinary double-deck cars on curves of radii varying from 36 to 400 feet. These are obtained by finding the versed sine formed by a chord of 22 feet cutting the various curves, and adding the small versed sine made by the overhang of the wheel base of the outer car, as shown in Fig. 4. The chord of 22 feet is the length of straight on the car, beyond which the overhang is not affected.

For a 40-feet curve, with a car 6 feet 7 inches in width, and 4 ft. 8½ in. gauge, the minimum distance between centres of tracks would be:—

	ft.	in.
Overhang of car on straight track	1	10½
Extra overhang on curve	1	7¾
Minimum clearance allowed	1	3
Gauge	4	8½
Centres	9	5¾

The overhang may also be obtained by using a piece of cardboard the shape of the car, having cut out a rectangle the size of the wheel base and gauge, and fitting it on to the curves of the required radii.

The gauge around a curve should be widened according to the radius. In Table No. 2 is given, to the nearest $\frac{1}{64}$ of an inch, the extra widths required for 3 ft. 6 in. and 4 ft. 8½ in. gauges respectively, and radii varying from 35 to 100 feet, obtained by ascertaining the difference in versed sines on inner and outer rails with a chord of 6 feet (wheel base).

To keep a presentable cross section of street it is not always possible to give the necessary amount of cant required for certain speeds around curves. It is especially important to approach as nearly as possible the cant required, where a curve occurs at the foot of a gradient. Applying the formula for centrifugal force:—

$$\frac{w\,v^2}{g\,r}.$$

then, where v and g = velocity and force of gravity respectively, in feet per second, and h, l and r = cant, gauge and radius respectively in feet, sliding force towards centre = centrifugal force, or

$$\frac{w\,h}{l} = \frac{w\,v^2}{g\,r}.$$

Therefore

$$h = \frac{v^2\,l}{g\,r}.$$

With 4 ft. 8½ in. gauge, and a curve of 50 feet radius, the cant necessary for a speed of 6 miles per hour works out at 0·208 feet, or 2½ inches, thus emphasising the need for cautious driving round curves where the necessary cant may not be obtained owing to reverse cross-fall of street, etc.

Where single track construction is adopted, care should be taken to place the loops in such positions that there is uninterrupted sight from one to the other, or a troublesome system of electric signalling has to be resorted to. Even then, however, cars will occasionally meet on the single line, causing delays.

Levels should be taken with some accuracy, and especially cross sections, in order to determine the amount of cross-fall to be given at any particular point. With ordinary double track on the straight, and normal cross-fall of street, a cross-fall of ¾ inch may be given from inner to outer rail; and a camber of

¾ inch on the paving between the rails. An even contour may be obtained, where the track and sides are paved with wood, by keeping down the outer rail 1⅛ inch and giving ⅜ of an inch camber on the paving between each track.

In many towns there is a great tendency to keep the paving from rail to kerb too flat; a cross-fall of ⅜ and ½ inch to the foot for wood and granite paving respectively is not excessive, except for steep gradients, where the cross-fall may be reduced.

Toothed margins, while more difficult to keep macadam up to, are less likely to have a deep groove at the edge of the paving.

Joints of paving should be as close as possible, in order to avoid the excessive wear which accompanies wide joints by wheels jumping from one side of the joint to the other, breaking off the arrises, and thus causing the joint to become wider and wider.

LAYING THE PERMANENT WAY.

The method of first crowing the rails, and, while supported at the required levels, packing above and below the rail flanges with concrete in one operation, is now more generally adopted, and has much to be said in its favour. If the concrete is not too wet, a solid bearing can be obtained for the underside of the flange, and the concrete above resists lateral, vertical, or creeping movements. In smaller towns, where a sett 4 inches in depth can be used, the depth of concrete over the flange necessary for this purpose can be obtained. In larger towns, where a 5-inch sett must be used, the same result could only be obtained either by deepening the web, and consequently weakening the rail to some extent while increasing its weight, or by cutting the sett as shown in Fig. 5, Drawing No. 3.

The old method of laying the concrete bed first, and then packing under the flange with cement and granite chippings, has been proved to cause endless annoyance. The packing penetrated little more than an inch on either side, leaving the central portion of rail flange entirely unsupported. When the weight was brought on, the flange either bent or the packing was crushed, resulting in a loose rail after a short time.

With the method previously mentioned a much better "top" can be obtained, and sags and rolls in the original road-surface taken out while the rails are being laid.

MAINTENANCE.

To avoid undue waste of current, regular attention should be paid to clearing out grooves of rails and watering of track.

With heavy traffic, and probable corrugations in the surface of the rail, a rail grinder is a necessity; but full benefit is not derived from its use if the joints are not secured.

Where unusual street traffic is experienced, chilled cast-iron paving blocks may be laid, abutting on the rails alternately with granite.

Much that might be added about the results of using various kinds of paving material will be reserved for a possible future contribution.

TABLE No. 1.—ALLOWANCE TO BE MADE FOR OVERHANG OF ORDINARY DOUBLE-DECK CARS ON CURVES.

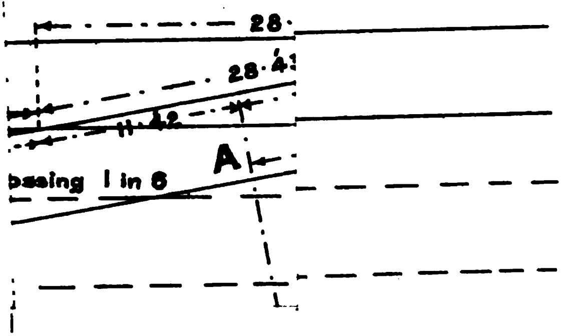
Radius to Inner Rail.	Overhang.		Radius to Inner Rail.	Overhang.	
feet	ft.	in.	feet	ft.	in.
36	1	10½	80	0	9¾
38	1	8¾	90	0	8½
40	1	7¾	100	0	8
42	1	6¾	120	0	6½
44	1	6	140	0	5½
46	1	5	170	0	4¾
50	1	3¾	200	0	4
55	1	1	250	0	3
65	1	0	300	0	2½
70	0	11	400	0	2

TABLE No. 2.—EXTRA AMOUNT TO BE ADDED TO GAUGE OF TRACK ON CURVES WITH A 6-FEET FIXED WHEEL BASE.

Radius to Inner Rail.	Extra for 3 ft. 6 in. Gauge.	Extra for 4 ft. 8½ in Gauge.
feet	inch	inch
35	$\frac{9}{64}$	$\frac{3}{16}$
40	$\frac{7}{64}$	$\frac{9}{64}$
45	$\frac{3}{32}$	$\frac{7}{64}$
50	$\frac{5}{64}$	$\frac{3}{32}$
60	$\frac{1}{16}$	$\frac{5}{64}$
70	$\frac{3}{64}$	$\frac{1}{16}$
80	$\frac{1}{32}$	$\frac{3}{64}$
100	$\frac{1}{64}$	$\frac{1}{32}$

OR

PLATE NO. 1.



CALCULATIONS FOR TURN-OUTS.

Cross-Over.—With a crossing of 1 in 6, tangent of half angle equals $\frac{1}{12}$ = ·0833. Therefore, half angle = 4° 46′, and total angle of crossing = 9° 32′.

This angle is equal to that subtended by the arc which is required to connect the straight to the line of crossing.

To find length of tangent A B in Fig. 1, tan $4° 46' = \frac{AB}{\text{radius}}$

A B = tan 4° 46′ × radius = ·0833 × 200 = 16·66 feet.

Outer tangent = tan 4° 46′ × 204·708 = 17·01 feet.

Other lengths are then calculated by the relation of the sines to their opposite sides, each angle, other than a right angle, being either 9° 32′ or 80° 28′, and the base either 4·708 feet (gauge) or 3·79 feet (centreway).

To find length of inner arc A C:—

$$\frac{AC}{\text{circumference}} = \frac{\text{angle subtended by arc}}{360°};$$

therefore

$$AC = \frac{2\pi r \times 9{\cdot}53°}{360°} = 33{\cdot}26 \text{ feet.}$$

Each side of the cross-over is a reverse duplicate of the other.

The toe of the points is set back 18 inches from the tangential point, as this portion is practically straight.

Diamond Turn-out.—In Fig. 2, a length of 15 feet has been taken from the tangential point D to heel of points E. This subtends an angle of 4° 17′.

The angle of crossing always equals the sum of the angles subtended by the arcs which are lettered D E and F G, and as the angle subtended by D E equals 4° 17′, then the angle subtended by F G will equal 9° 32′ − 4° 17′ = 5° 15′.

Then inner tangent D H = tan 2° 8′ 30″ × 200 = 7·47 feet, and inner tangent F K = 2° 37′ 30″ × 200 = 9·16 feet.

The arcs connecting the double line to the line of crossing are similar to those from single line to crossing.

COST OF PERMANENT WAY PER LINEAL YARD OF SINGLE TRACK.

Gauge 4 ft. 8½ in.

	£	s.	d.
Rails, 100 lb. × 2 = 200 lb., at 6*l.* 10*s.* per ton	0	11	7·28
Fish-plates, 98 lb. to 20 yards of track = 4·9 lb., at 7*l.* 5*s.* per ton	0	0	3·81
Fish-bolts, 29 lb. to 20 yards of track = 1·42 lb., at 14*l.* per ton	0	0	2·13
Tie-bars, 11¼ lb. to 2½ yards of track = 4½ lb., at 9*l.* 5*s.* per ton	0	0	4·46
Copper bonds—			
30 in. bonds, No. 4, to 20 yards of track = 0·2, at 11*l.* 5*s.* per 100	0	0	5·40
60 in. bonds, No. 1, to 50 yards of track = 0·02, at 21*l.* 15*s.* per 100	0	0	1·04
48 in. bonds, No. 1, to 100 yards of track = 0·01, at 17*l.* 15*s.* per 100	0	0	0·42
Labour, bending and laying rails, etc.	0	1	6
Carting and delivering rails and accessories alongside work	0	0	6
Excavation, 0·907 cubic yards, at 3*s.* 9*d.* per cub. yd.	0	3	4·81
Concrete, 0·495 cubic yards, at 16*s.* per cubic yard ..	0	7	1·04
5 in. granite paving, 2·69 superficial yards, at 10*s.* 6*d.* per superficial yard	1	8	2·96
Making good macadam margins	0	1	3
Total	£2	15	0·35

DISCUSSION.

Mr. A. D. GREATOREX: I should like to propose a hearty vote of thanks to Mr. Owen for the extremely interesting and useful paper he has placed before us. All those who have anything to do with tramways are anxious to receive up-to-date information on the subject. Although it is only a few years ago since many of the tramways in this country were laid down, we can see them going to pieces. Therefore, if we can gain any information, even from the younger members of the profession, we are anxious to do so. With respect to diagram No. 3, I would like some information as to how long this special joint has been in operation, and some information as to the towns which have tried it. It appears to me that the whole weight of the cars would go on the screws. If you have cars like we have in the Black Country, of 10 tons in weight carrying 70 passengers, it is a very heavy weight on the screws. I should like to have some information, if Mr. Owen can give it, as to where it has been tried. Then there is the question of the expansion joint. I do not altogether agree that it is a mistake to leave room for expansion, and that the rails should be laid butt up. At the great speed at which the cars run there is cold rolling taking place in the rails. I can show rails which have been down two or three years where you could not insert the end of the blade of a penknife, and that in a case where a joint had been left open ⅛ inch. It is not expansion, but the rails have rolled from the continual running of the cars in one direction. Going back to the question of the joints, all of you who have anything to do with tramways must be anxious to find how to get rid of the trouble with the joints. I am convinced that not only should joints be anchored, but that the rails should be anchored. If I had to lay another tram track, I should anchor at every 6 feet. I am not in favour of a 60-feet rail; I think 45 feet is long enough to deal with. As to the setting out of the curves, the particulars will be very useful to the members of the Association, and it is very good of Mr. Owen to give us the particulars he has worked out. With reference to the instance given by Mr. Owen, I can hardly understand that the gauge should have altered as much as 10 inches. I have not seen anything approaching that, and would much have liked to have seen it. I do not know whether Mr. Owen is referring to the trams in Colchester, and had anything to do with the laying of them. I saw them the other day, and I must say the work looked very well done indeed.

Mr. E. J. **Elford**: I should like to second the vote of thanks as one who is interested in tramway construction. The only point I want to refer to is one Mr. Greatorex has spoken of—the movement of rails resulting from variations of temperature. I can quite support the statement of Mr. Owen from personal experience. On one occasion I saw a length of track move laterally a distance of 18 inches during twenty-four hours.

The **President**: There are only one or two things I should like to say. In Norwich the tramway is somewhat unique—in fact, it is unique. I believe it is the lightest section of rail allowed by the Board of Trade for any electric tramway originally constructed as such. The rails here are about 64 lb. to the yard. The rails have been laid and some of the tracks have been working for about five years and you have the greatest difficulty to find the joints. They are all laid on the cast weld system. I don't know that there is a defective joint in the 17 or 18 miles of track. There is not the slightest trouble from these joints. I attribute the satisfactory wearing of the tracks to a reasonable amount of anchoring and good jointing. The rails are anchored at about every 12 feet. Of course, rails have been renewed which have in relaying been jointed with fishplates or thermit joints. The reason for using the thermit, which is a good joint, is that you require to have so much apparatus for the cast weld that, unless there are 20 or 30 to make, they are not worth doing. If I were about to lay a system of tramways, I should adopt the cast weld or the thermit-joint. I quite agree with the Author as to widening the groove at curves. At curves of less than 100 feet we have in Norwich a groove of 1⅜ inch, which enables the cars to move around the grooves very well. The trams here were laid by a company, but I supervised their construction on behalf of the Corporation.

Mr. J. Owen, in reply, said: The first point raised is the concentration of the weight on the two screws of the joint-plate. Naturally, if they were not strengthened in some way, the thread would be stripped and the rail-support become absolutely useless. The inventor, however, had the advantage of the assistance of a gentleman who served on the British Standards Committee for Threads, and in consequence has been able to so strengthen the supporting screws that there is no danger of stripping. The cast-iron base-plate is sufficiently strong to resist any crushing tendency due to this concentration of weight and within a very short time of being inserted, will take up a firm bearing on the concrete.

Mr. Greatorex asks, "Where has the joint-support been tried under working conditions?" As mentioned in the paper several "knocking" joints in the Manchester track have been remedied and are now in a perfect condition although subjected to the test of a one-minute service.

Mr. Greatorex: Is that in Piccadilly?

Mr. Owen: Yes. I think there are few places where such a severe test could be imposed as in the case of Piccadilly, Manchester, where an enormous amount of traffic is experienced.

Mr. Greatorex says further that he advocates an open joint. Personally, I think this is a mistake to which the corrugation mentioned might be traced, and no doubt is largely intensified by loose joints. If the joints are perfectly rigid, there will, in my opinion, be no corrugation encountered. Moreover, it appears to me unnecessary to anchor the rail at every 6 feet. I should think it quite sufficient to have anchor plates at the joints, and three intermediates in a 60-feet rail if the rails are laid after the concrete; but even these might be dispensed with, if the rail flange is embedded in the concrete.

With regard to the question of widened groove, this is met with by the adoption of the section, recommended by the British Standards Committee, for curves of less than 100 feet radius, which has a groove of 1¼ inch.

Then a point was raised as to the gauge having altered as much as 10 inches. The track was laid during a hot day and in the early part of the evening I passed it ready for concreting. Next morning, however, I thought a traction-engine had been over the track, as every tie-bar had buckled, and the rails were off the packings. This I put down to the fact that the pulling effect due to contraction on the straight does not move the track out of line to any appreciable extent, but on the curve any shortening is very apparent.

I must thank Mr. Greatorex for his kind reference to the Colchester Tramways, of which, I may say, I had entire supervision under Mr. Goodyear, the borough engineer. I also thank you, Mr. President, and gentlemen, for the kind attention you have shown to a young member who has had the presumption to read a paper before you; but your sympathy will help and spur me on to further efforts in the near future.

THE WATER SUPPLY OF CROMER.

By THOS. PRITCHARD, M. Inst. C.E.

The public supply of water to Cromer was originally designed and carried out in the year 1877, and intended to meet the then present requirements of Cromer—at that time only a small seaside village, ten miles from a railway station, with but few summer visitors.

With the advent of first the Great Eastern and afterwards the Great Northern and Midland Railways, the village grew into a considerable sea-side resort, and the waterworks have from time to time been enlarged to meet the growing requirements of the district.

The works were originally carried out by a water company, which, with varying fortunes, conducted the business until the year 1902, when it was acquired by the urban district council.

The original works carried out by the company, of which Mr. Hodgson Jones, M. Inst. C.E., was the engineer, comprised a pumping station, situate on the west side of the Roughton Road, having a well (No. 1) 6 feet in diameter, sunk 83 feet, with a borehole varying from 12 inches to 9 inches in diameter, sunk to a depth of 400 feet into the chalk.

This shaft was originally intended to have been taken to a depth of 150 feet, and to be lined with 9-inch brickwork, but in the total absence of any information as to the nature of the strata beyond the depth to the blue clay, it was uncertain whether the means available would be sufficient to do so. It was assumed that the clay would lead into the chalk, and no sand would be met with.

Water being met with in the sinking in such large quantities that cast-iron cylinders had to be inserted, and the cost entailed thereby, and the pumping caused the shaft idea to be abandoned, and boring was resorted to.

The strata passed through in sinking this well and borehole were:—

		Thickness.		Depth.	
		ft.	in.	ft.	in.
	Soil	2	0	2	0
Contorted drift, 111½ feet.	Brick earth	8	0	10	0
	Loamy sand	9	0	19	0
	Brown clay and chalk	6	0	25	0
	Sand	2	6	27	6
	Blue loamy clay	14	6	42	0
	Brown sand and pebbles	18	0	60	0
	Running sand, with water	19	0	79	0
	Silt	4	6	83	6
	Light brown clay	6	0	89	6
	Dark brown clay	6	0	95	6
	Light loamy clay	5	0	100	6
	Hard dark sand	1	0	101	6
	Dark running sand	1	6	103	0
	Hard dark sand	6	6	109	6
	Running sand	4	0	113	6
Pliocene beds, 29¼ feet.	Hard blue clay	7	0	120	6
	Hard flinty conglomerate	18	0	138	6
	Black flint	–	6	139	0
	Chalk and silt	3	0	142	0
	Black flint	–	9	142	9
	Blue silt, with little chalk	26	0	168	9
	Into chalk	231	3	400	0

The chalk was solid, with an average of beds of flints 3 feet to every 10 feet of chalk.

The bore-pipe was taken 10 feet into the chalk, but after the pumps were fixed this was found to be insufficient to keep out the sand. This pipe was pressed a further 20 feet into the chalk, but as sand was found to be in the water at times, other means had to be found to exclude the sand. A clay and cement joint was put lower into the chalk, and a guide pipe pressed into same and brought up in the bore-pipe with the space filled with cement. This had the desired effect, and sand was permanently stopped out.

The pumping plant consisted of a 10 horse-power horizontal engine by Hanna Donald Wilson, driving a bore-hole pump. Steam was supplied from an oval boiler, 4 feet by 4 feet 6 inches by 18 feet 6 inches long.

A covered service reservoir holding 120,000 gallons was constructed on the high land above the town, and a house for the manager was built at the pumping station.

In 1887, it was necessary to obtain an additional supply when a second well and bore-hole were sunk 30 feet to the north-ward of No. 1 well, the well being brick-lined for a depth of 12 feet and a 12-inch boring carried down 242 feet into the chalk, being lined with steel bore-hole pipes for a depth of 172 feet 9 inches; the remainder being in the chalk was unlined. A 9-inch bore-hole pump capable of lifting 6000 to 7000 gallons per hour was fixed in this well, driven by the before-mentioned engine.

The engine and boiler erected in 1877 are still being used, and with this pump form a duplicate plant at the old station. An additional boiler, 5 feet 6 inches diameter by 9 feet 6 inches long was erected in 1887.

The whole of the machinery is overhauled annually in the spring before the Cromer season commences.

In the year 1888, Mr. J. C. Melliss, M. Inst. C.E., was consulted on the question, and since that time has acted as engineer for the company and the council since the transfer of the works, the Author having been associated with him since 1891.

Owing to the increased demand for water, a contract was entered into at the commencement of 1889 to deepen well No. 1 to a depth of 136 feet, which would have allowed of adits being driven in the chalk.

It was proposed to carry out this work in the following manner: The existing cylinders were to be made secure from travelling, the concrete bottom cut out and the guide pipes removed, the excavation taken down to about 118 feet and lined with brickwork, there would have been no water to contend with until a depth of about 110 feet was reached; cast-iron cylinders were then to be inserted and carried down to the chalk with perforations to take the water in conglomerate bed.

On account of the old part of the well collapsing during the further sinking, the work had to be abandoned, and it was decided to start a new well referred to as No. 3 about 15 feet to the south of No. 1, the reason of sinking so close being that the company had to keep the works within their original area which they were unable to extend.

Well No. 3 was sunk to a depth of 183 feet, lined with brickwork to a depth of 50 feet, continued with cast-iron cylinders varying from 8 feet to 5 feet in diameter into the chalk; a 12-inch bore-hole was carried 40 feet down from the bottom of this well. The contract time for completing this work was seven months, but on account of the difficulties met with it was upwards of two years in construction.

The strata passed through were as follows, the surface level being 132 feet above Ordnance Datum:—

	Thickness.		Depth.	
	ft.	in.	ft.	in.
Soil	2	0	2	0
Brick earth	8	0	10	0
Loamy sand	9	0	19	0
Brown clay	6	0	25	0
Sand	2	6	27	6
Blue loamy clay	14	6	42	0
Brown sand and pebbles	18	0	60	0
Running sand	19	0	79	0
Silt	4	6	83	6
Light brown clay	6	0	89	6
Dark brown clay	6	0	95	6
Light loamy clay	5	0	100	6
Hard dark sand	1	0	101	6
Dark running sand	1	6	103	0
Hard dark sand	6	6	109	6
Running sand	4	0	113	6
Hard blue clay	7	0	120	6
Flinty conglomerate	18	0	138	6
Into chalk	84	6	223	0

This well was connected with No. 2 well by an adit curved round so as to miss No. 1 well (which was filled in with spoil from No. 3 well), so that the water obtained in both No. 2 and No. 3 would be available at either well. As a fissure was visible on the north face of the well, an adit was cut to follow it for a distance of about 50 feet.

The rest water line was 111 feet below the surface and the yield from the wells and adits at this time amounted to 200,000 gallons per day.

This water was analysed by Professor Frankland with the following results:—

	Parts per 100,000.
Total solid matters	30·00
Organic carbon	·070
Organic nitrogen	·020
Ammonia	·0
Nitrogen as nitrates or nitrites	·015
Total combined nitrogen	·035
Previous animal or sewage contaminations ..	·0
Chlorine	3·8

Hardness, temporary	12·7°
„ permanent	4·4°
Total	17·1°

Professor Frankland stated in his report: "The water is of most excellent quality for dietetic purposes, absolutely free from all evidence of previous sewage or animal contaminations, and of very moderate hardness for chalk water, and Cromer may be congratulated on being supplied with one of the best waters in Great Britain."

A 16 horse-power horizontal steam engine, having 13-inch diameter cylinder with 24-inch stroke (with surface condenser), driving a set of 7½ inch by 21 inch stroke treble pumps capable of raising 200 gallons of water per minute 300 feet high, was installed by Messrs. J. Warner and Co., of Walton-on-the-Naze, in 1892.

Towards the end of 1895, owing apparently to dry seasons, the yield of the wells had fallen to 63,000 gallons per day with a water level about 50 feet below sea level. It became necessary to obtain an additional supply; rights were obtained from the owner to drive adits in the chalk under 13 acres of land to the south of the pumping station, and by May 1896, 400 feet of adits, 4 feet 6 inches wide and 6 feet high, were driven east and west of original heading which, after continuous pumping during their construction, brought up the yield to 190,000 gallons per day. This was sufficient to last for another two years when it was decided to further increase the length of adits by 300 feet which brought the yield up to 254,640 gallons per day.

At this time, the water was being obtained as follows:—

	Gallons.
From wells Nos. 2 and 3, and connecting adit	35,000
From the eastern heading	69,114
From the western heading	150,526
	254,640

thus showing that the bulk of the supply came from the south of the works, i.e. inland and not from seawards.

The rest water level in well in 1900 was 100 feet below surface, showing that the water in the ground had been permanently lowered about 11 feet in twenty-three years.

By September 1902, when the test pumping for arbitration purposes was made, it was found that the yield from the works had again fallen to 160,000 gallons per day, and as it would be some time before the auxiliary works, hereafter described, would be available, it was decided to further extend the adits, when, by driving a further length of 265 feet, the average quantity shown by a five days' test amounted to 296,000 gallons per day. Since this time there has been no test of the quantity available, so one cannot say what it is; but during last summer the yield did not appear to have seriously fallen off.

In 1895 it was considered that the original service reservoir was inadequate for the needs of the district, and an additional covered reservoir, holding 605,000 gallons, was constructed in concrete lined with blue brickwork. The depth of water in this reservoir is 17 feet, and when filled for testing purposes was found to leak at the rate of about 3½ inches per day, it was emptied and examined by the clerk of works and supposed to have been made good, but it turned out to be as bad as ever, so the Author went down and examined practically every joint in the brickwork, when he found that, on account of the thinness of the joints, the sand, which had not been properly cleaned off the bricks, had prevented the cement making a sound joint. All visible faulty joints were cut out, caulked with oakum, and repointed, with the result that this reservoir is now perfectly watertight. A Jennings' electric indicating and recording apparatus is fitted in this reservoir with indicator fixed in the engine house, so the height of water in the reservoir can be seen at a glance at any time.

In 1896 the boundaries of Cromer were extended so as to include Suffield Park, and it was decided to supply that district, but as it lay higher than the reservoirs, and as there was no available land high enough to command the added district, it became necessary to construct a brick water-tower, carrying a cast-iron water-tank holding 50,000 gallons, near the Great Eastern Railway station. The top water-level is 45 feet above the roadway and about 90 feet above the reservoirs. The tower is supplied by a by-pass on the rising main to reservoirs. An electrical signalling apparatus was installed in this tank by the Post Office authorities, ringing separate bells in the engine house when the water level is within a foot either of the top or bottom; this apparatus appears to be very successful, as whenever the Author has been in the engine house since he has always found both bells plugged with waste.

All the before-mentioned works have been carried out under the original provisional order and water bill, which gave the company powers to supply the parishes of Cromer, Overstrand, Northrepps and Runton, but limited their liability to that part of the district which could be commanded by the level of the then proposed reservoir, this being only 150 feet above Ordnance Datum and as parts of the district rise to over 200 feet, these parts could get no supply had they wanted it.

In the year 1900 it was considered advisable, not on account of any failure in the existing works, but in consequence of the growth of population in many of the surrounding places, for the company to go further afield to secure a larger supply of water. For this purpose it was decided that auxiliary works would be advantageous on account of the increased quantity of water that would be available, as well as on account of the benefit that would arise by having a service reservoir placed on the highest ground in the neighbourhood, which would give sufficient pressure to supply the whole of the company's district, and allow that district to be considerably extended.

Before deciding upon the site for such auxiliary works Mr. Clement Reid and Mr. William Whitaker were consulted on the geological aspect of the question.

There appeared to be but two possible sources of supply, firstly, from the sands and gravels lying above the chalk, and secondly, from the chalk itself, which in this district is estimated to be about 1000 feet thick.

There is no spring or set of springs in the neighbourhood likely to yield a sufficient supply. Doubtless much water might have been obtained, at little expense, by careful trenching; but it was feared that the Local Government Board would have objected to this source of supply on account of the risk of contamination from the extension of building on the hills around Cromer, where the gravel is bare and very porous.

The sands and gravels lying at a greater depth were not considered likely to yield sufficient water, and that probably harder and not so suitable as that from the chalk; therefore the idea of getting water from the upper strata was abandoned, and it was considered that the only satisfactory means of supply, was by sinking into the chalk at such a distance from the sea as would allow of pumping without fear of the influx of salt water, and sufficiently near the gathering ground as to allow the water passing more readily than it can into the existing wells and adits.

A site was decided upon in the valley at Metton about four miles to the south of Cromer, and the same distance from the sea, where it was considered the chalk would be met with about 10 feet above Ordnance Datum (as a matter of fact, the chalk was touched at 12 feet above Ordnance Datum). A site having an area of one acre was acquired for the well and pumping station, together with the right of driving adits in the chalk under the surrounding lands.

The Cromer Water Act, 1901, was obtained, giving the company powers to carry out the proposed works (which lay entirely without their original area), and extended their operations to a radius of five miles round Cromer. After the company's Bill was deposited, they were approached by the urban district council, and it was agreed to insert a clause giving the council power to acquire the undertaking of the company by arbitration, this power was exercised in 1902, since which time the works have been the property of, and managed by, the council.

A test borehole was sunk on the site at Metton in 1901, 8 inches in diameter and 203 feet deep, lined so as to exclude all water lying above the chalk, when the water flowed over the surface, and has been overflowing ever since.

The geological formation passed through was as follows, the surface level being 118 feet above O.D. :—

		Thickness.		Depth.	
		ft.	in.	ft.	in.
	Soil	1	0	1	0
Glacial	Gravel	5	0	6	0
	Boulder clay	24	0	30	0
	Sand and boulder clay	20	0	50	0
Forest bed	Coarse-grained blowing sand, pebbles, green flints and shells (*Cardium edule, Tellina balthica*) ..	11	0	61	0
Weybourn crag and Chillesford clay	Fine running sand and stones (*Littorina, Cardium edule, Corbula, Mytilus, Nucula Cobboldiæ, Pholas, Tellina balthica*	10	0	71	0
	Running sand, with veins of micaceous clay and pebbles	34	0	105	0
	Shells and green coated flints (*Cardium edule, Cyprina islandica, Leda, Mya, Nucula Cobboldiæ, Tellina balthica, T. obliqua, Littorina Littorea*)	1	0	106	0
	Chalk, to and beyond	..		208	0

A small Worthington pump and semi-portable boiler was put down at this borehole, capable of lifting 6000 gallons per hour, and has been used during the summer season to augment the supply.

The permanent well has recently been completed; it is 160 feet deep, lined from the surface to 125 feet with cast-iron cylinders 1¼-inch thick, built up in seven segments to each ring. From the bottom of this well a 12-inch diameter borehole has been sunk 100 feet. This well had to be 10 feet in diameter throughout to allow of the pumps being fixed, and on account of the slippery nature of the ground, the contractors fixed an outer column of cylinders 12 feet in diameter down for 50 feet, and sunk the permanent cylinders inside them. This proved a very efficient way of overcoming any difficulty from the permanent cylinders becoming stuck or out of plumb. It had been intended to remove the outer cylinders on completion of the work, but this was not allowed in order to avoid any possible damage that might have occurred to the permanent work, and to save any further subsidence which might affect the foundations for the machinery and buildings, as during the pumping the ground had considerably subsided over an area of about thirty feet in diameter. These two columns of cylinders are now bracketed together, and the space filled in with sand.

Adits have been driven from this well to connect with the test borehole, and in following fissures which appeared, the total distance driven being 417 feet.

It had been hoped to have obtained a supply of 1,000,000 gallons a day at the new works, so as to insure an abundant supply for many years to come; but this quantity was not reached (although there is no doubt that by extending the adits it would have been), and as the Council considered they had expended as much as they were justified in doing, the work was stopped and the yield was proved on testing to amount to 730,000 gallons per day obtained in the following proportions:—

	Gallons.
From the well	284,400
„ bore-hole	123,100
„ test bore-hole	90,000
„ adits	232,500
Total	730,000

This amount equals about 2½ times the maximum day's demand, which at the height of the last season, amounted to just over 300,000 gallons.

The whole of the well sinking, boring and adits described herein has been carried out by Messrs. T. Tilley and Sons.

The pumping station when completed will comprise the following:—boiler house with two Galloway type boilers, engine house with pumping engines in duplicate, coal store, workshop, office, mess-room, etc., together with engineer's house.

The Council, considering the comparatively great expenditure on the undertaking and that they had the old works to depend upon for that part of the district requiring the greater supply, and with the small pump in test borehole at Metton for the higher portion, which together make practically a duplicate plant, decided to carry out only so much of the new pumping station as was absolutely necessary, and this work which is at present being carried out comprises the permanent boiler house with one boiler and a space for a second, chimney shaft, temporary engine house, with one set of pumping plant, temporary coal store and the engineer's house.

The boiler which is being manufactured by Messrs. Ruston, Proctor and Co., is a "Galloway" type boiler, constructed for 100 lb. pressure, 6 feet in diameter and 18 feet long, and guaranteed to evaporate 3000 lb. of water per hour.

The pumping plant is being manufactured by Messrs. J. Simpson and Co., and is at present ready for erection; it is to be capable of raising one million gallons in twenty-four hours from the bottom of the well, and forcing it through 13,000 feet of 12-inch rising main into reservoir, the vertical lift from bottom of well to engine-house floor is 160 feet and from engine-house floor to reservoir inlet 190 feet exclusive of friction.

The pumps are arranged to do the work in two lifts, i.e.:—

(*a*) Well lift, which raises the water to a pumping sumph under engine-house floor, and

(*b*) Surface lift, which forces the water through the main into reservoir.

This arrangement was adopted in case it should become at any time necessary to soften or otherwise treat the water before use.

The engine is a cross-compound rotative surface-condensing engine, having 14-inch high-pressure and 25-inch low-pressure cylinders with 24-inch stroke running at 60 revolutions per minute, developing at 90 lb. steam pressure at the valves 81 pump horse-power on a guaranteed consumption of not more than 22·9 lb. of feed-water per pump horse-power hour under a forfeit of 500*l.* per excess lb. of feed-water as tested by a twelve hours' run.

The well-pumps are hung from the well-head and are double-acting, having two barrels in the same column (concertina arrangement); the pump barrels are 15 inches in diameter with 26-inch stroke, making 23½ strokes per minute, driven by gearing and crank shaft.

The surface-pumps are two double-acting plunger pumps, 7 inches diameter by 24-inch stroke, making 60 strokes per minute, driven direct from the engine by prolongation of piston rods.

The surface-pumps are designed with a margin of 3 per cent. greater than the actual work required and the well-pumps are 10 per cent. larger than the surface-pumps to provide for slip, evaporation, etc., and to maintain a balance in excess of the surface-pump capacity.

The whole of the steam-pipe work, feed-pumps, air-pumps, gauges, together with oil-extractor, feed-water purifier and softener, etc., are included in Messrs. Simpson's contract.

The high level reservoir has been constructed on the high land near the Beacon and just above the Lion's Mouth about 3½ miles from Cromer, and the floor level is 301·5 feet above O.D. and is at a sufficient elevation to supply the whole area. It is constructed of concrete lined with blue brickwork, and has a capacity of one million gallons with division wall to allow of cleansing half at a time. A Glenfield electrical indicating and recording apparatus is installed at this reservoir, with recorder at pumping station, and each station is connected with the waterworks manager's office in Cromer.

A service main of 15, 12, 9 and 6-inch pipes is laid from this reservoir to Cromer and connected with the old reservoirs, water tower and the mains to the higher portions of the area now supplied, and arrangements have been provided for putting the full-pressure on to the mains in the town in case of fire.

There are about 17 miles of cast-iron service and pumping-mains varying in size from 3 inches to 15 inches, extending from

Metton on the south to Runton on the west and Sidestrand on the east, and arrangements have already been made for extending the area supplied, and doubtless as soon as the new works are in working order they will be greatly extended.

Since the public supply of water was established, there has never been a shortage in the supply, as the authorities always used the foresight necessary to maintain the works at the necessary standard. The water has been uniformly good, and only on one occasion has any doubt been thrown on the chemical or bacteriological quality of the water, and that was when traces of unwelcome bacteria were found in certain of the mains (samples taken from the reservoirs and other mains at the same time were favourably reported upon), these were run to earth in certain dead ends where there were no connections. These ends have been connected up or otherwise dealt with, since which time there has been no cause for criticisms.

The various works carried out for obtaining water at Cromer point out the advantage of wells over boring to the chalk, as it is necessary to get at the fissures which by a bore-hole might be missed by a few feet, whereas, with a well they can generally be found by adit driving.

The company at the time of the transfer to the Council had a capital of 20,000*l.*, half in 10 per cent. " A " shares, and the remainder in 7 per cent. " B " shares, together with a debenture debt of 5000*l.*, bearing interest at 4½ per cent. The " B " capital had received their full dividends, but the " A " stock, since 1883, had received no dividend in eight years, 2½ to 5 per cent. in five years, and for the last seven years the dividend had been 7 per cent. per annum. There was, therefore, an amount equal to about 117¾ per cent. of the " A " capital due on them for arrears in dividends.

The amount awarded the company for their undertaking was 59,302*l.*, the Council to take over the debenture debt of the company, which has since been redeemed, the Council also to pay the costs of obtaining the 1901 Act and the winding-up of the company, together with any expenditure by the company on works carried out under the 1901 Act.

The capital return to the shareholders was 19*l.* 11*s.* 5*d.* together with arrears of dividends per 5*l.* " A " share, and 11*l.* 4*s.* 1*d.* per 5*l.* " B " share.

The total expenditures on the undertaking by the council is now approaching 100,000*l.*

The authorised rates for domestic supply, as fixed by the original Act, and confirmed by the 1901 Act, are as follows:—

	Per annum. £	s.	d.
Where the rateable value of the premises does not exceed £5 per annum	0	10	0
Ditto, exceeds £5 but does not exceed £10	0	16	0
„ 10 „ „ 15	1	4	0
„ 15 „ „ 20	1	12	0
„ 20 „ „ 25	1	19	0
„ 25 „ „ 30	2	6	0
„ 30 „ „ 35	2	13	0
„ 35 „ „ 40	3	0	0
„ 40 „ „ 45	3	6	0
„ 45 „ „ 50	3	12	0
„ 50 „ „ 55	3	18	0
„ 55 „ „ 60	4	4	0
„ 60 „ „ 65	4	9	0
„ 65 „ „ 70	4	14	0
„ 70 „ „ 75	4	19	0
„ 75 „ „ 80	5	4	0
„ 80 „ „ 85	5	8	0
„ 85 „ „ 90	5	12	0
„ 90 „ „ 95	5	16	0
„ 95 „ „ 100	6	0	0
„ 100 six per cent. per annum			
For every w.c. beyond the first	0	10	0
„ bath of 50 gallons	0	12	6
„ „ of more than 50 gallons, as the company think fit.			

Water for street watering, sewer flushing, etc., was supplied to the council, by agreement, at 1*s.* 6*d.* per thousand gallons, plus a rental of 14*l.* per annum for rent of hydrants.

The quantity of water pumped during each of the last five years of the company were:—

	Gallons.
1898	33,672,000
1899	36,000,000
1900	40,000,000
1901	43,000,000
1902	47,317,000

The income, expenditure, and profit per thousand gallons pumped, were:—

Year.	Income. *d.*	Expenditure. *d.*	Profit. *d.*
1898	16·46	5·05	11·41
1899	17·84	7·69	10·15
1900	18·28	6·61	11·67
1901	19·01	5·42	13·59
1902	18·85	5·36	13·49

The cost of various portions of the work have been :—

	£	s.	d.	
Well and boring No. 2	770	0	0	
Well and boring No. 3, including adits 97 ft. long	2673	0	0	
Further adits from well No. 3 (company doing pumping and providing steam)	3	8	3	per yard.
Engine and pumps to No. 3 well	1308	0	0	
Reservoir containing 605,000 gallons	3809	0	0	
" " 1,000,000 "	5744	0	0	
Test boring at Metton	260	0	0	
Well at Metton, exclusive of bore-hole (including 14 days' test pumping)	5356	0	0	
12-in. boring (unlined) from bottom of well, including pumping	1	19	6	per foot.
Adits 4 ft. 6 in. by 6 ft., including pumping up to 750,000 gallons per day	7	10	0	per yard.
New pumping station, contract sum	2146	0	0	
6 ft. by 18 ft. Galloway type boiler, delivered on site	230	0	0	
New pumping plant	3464	0	0	

he prices paid for cast-iron mains, laid complete, have :—

	£	s.	d.	
15 in. diameter	1	1	3	per yard.
12 in. "		15	8½	"
9 in. "		12	5	"
6 in. "		6	2½	"
4 in. "		4	1½	"
3 in. "		3	4½	"

DISCUSSION.

he **President**: There are one or two questions I should to ask Mr. Pritchard. What total length of headings they at the present time at Cromer waterworks? What h they are below mean sea level? Is the water level lowered below mean sea level, and if so are there any signs filtration of sea water? I have had the same trouble in a of keeping out sand from the water, and excluded it in the manner. Instead of using clay, I injected cement. I d also like the cost of pumping per thousand gallons, and otal head of pumping.

Ir. A. D. **Greatorex**: I have great pleasure in proposing arty vote of thanks to Mr. Pritchard for the interesting description he has given us of the waterworks at Cromer. It is gratifying to know that Cromer has a good supply of pure water to drink. It is like a number of other places on the East Coast,—a place for visitors, and not a manufacturing town. Therefore it is gratifying to those who make it their place of visit to know that the water is both pure and of good supply. I have much pleasure in proposing a hearty vote of thanks to Mr. Pritchard for the paper."

Mr. W. Nisbet Blair: I rise to second the vote of thanks to the Author of the paper. It is useful, unquestionably, as being a record of fact that will be a guide to many of us in putting down borings. In St. Pancras, we have lately sunk three wells. In one case we have a deep well pump, and in the two other cases we lift the water by the air-lift system. That unquestionably proves more economical than the deep-well pump, and you are able also to get a greater delivery from any borehole than you can from a deep pump fixed in some borehole. It occurred to me whether Mr. Pritchard had considered the method of lifting water by the air-lift system, as any difficulty in getting the necessary quantity by a deep well pump would be overcome by the air-lift. The disadvantage we have in my own case, is due to the intermittent supply required. Our supply is not for potable water, but for swimming-baths; the water has, however, been analysed and proved to be an absolutely pure water. But you cannot get the same economy in pumping if you are running intermittently. The cost of pumping to us is about 2*d.* per 1000 gallons, whereas we had to pay a water company 9*d.* per 1000 gallons for the same quantity; or, rather, we could not then be so generous in the use of water as we are now that we are only paying 2*d.* per 1000 gallons. There is a further advantage in an air-lift where applied to a public bath. If you lift by a deep-well pump, you bring the water up at its normal temperature of 55° to 60°. If you bring the water up by an air-lift, it is delivered at about 70°. You have, therefore, no circulating to do to make it suitable for bathers, and we have found in both baths that we actually use less coal for raising steam for the pumps, or for the air-lift than we used before, when we only had to raise steam for circulating the water for heating. In other words, the coal used for raising the water is less than is required for heating it. I would like to ask Mr. Pritchard whether, in going down in the chalk, he found the water flow almost entirely from certain beds, probably flints in the chalk, and whether, by going down a further 100 feet, he got any tangible increase in the flow of the water. I know of a well—it does not belong to my Council, but to the Midland Railway Company—where they sank a well 9 feet in diameter down into the chalk until water came in very freely. They were pumping 40,000 gallons an hour. They employed large pumps to lift the water in order to sink the well further. They then started a 20-inch boring, and went down 200 feet into the chalk, and by running the same pumps at the same speed they found there was no additional water from that 200 feet of boring of 20 inches diameter. They abandoned the boring, drove headings at the level of the free flow of water, and they have undoubtedly increased the supply. There is a further point. I have proved that by going down into the middle chalk, you are apt to get a harder water than from the upper chalk. As a soft supply is preferable, that is another reason for not going deep. On the other hand, if you adopt the air-lift system, you require to go to a total depth about three times the actual depth at which the water flows. If you get water at 150 feet, you have to bore about 450 feet in order to use the air-lift system.

Mr. W. T. S. SCHLUND: With reference to the leaking of water from the reservoir, which is stated to have been at the rate of 3½ inches per day, it occurred to me that the caulking of the joints with oakum is not a sanitary thing to do, and that the staining of the water may be due to the presence of oakum. Then it occurred to me whether the oakum would not form a breeding ground for bacteria. The depth of the adits is not stated in the paper. I should like to know if divers were employed for the purpose, or whether the water was kept down by means of pumping to allow the men to work in the adits.

Mr. A. C. JAMES: I do not exactly see how the joint between the two tubes was made. Unfortunately I have not had any experience of waterworks, and I do not see how it is to be made watertight. With reference to the analysis of the water, I should like to know whether this is an average sample of the water, or whether the hardness increases in summer, or remains the same all the year round. There is one other point as to the infiltration of sea water. In my district we have the pumping station for practically the whole of South Essex, and the station is situate half a mile from the Thames. A complaint was made that the water was brackish. A sample was sent to be analysed by Dr. Thresh, who found that the water contained 70 grains of chlorine per gallon, and that about 6½ per cent. of Thames water was going in, making it dangerous to drink. That would not obtain in the case of Cromer, as it would be sea water going in, and would be simply unpleasant to drink.

Mr. T. **Pritchard**, in reply: The depth is 140 feet at the new well. The usual depth of pumping at old well is 50 feet below mean sea level, and we are situate about two-thirds of a mile from the sea. There has been no infiltration at all. Practically the whole of the water comes from the land side. For several years we have felt we might have the sea in at any time, and that is one of the reasons why the company decided to go further inland for their new works. We had power to drive headings at the old works, but the risk of sea infiltration was considered too great to be run any longer. The total pumping lift is 170 feet, 110 feet in the well and 60 feet to the reservoir, and with the 60 feet above ground we considered the air lift was hardly suitable. It means sinking the well much deeper and having a standpipe there. We had no power to do that. The original pump was in, and is kept as a duplicate for the new one. In the flint bands we found a good deal of water, but most of our water comes from fissures. By sinking the borehole deeper, we should get it from the flint, but not from the fissures. There are 417 feet of adits from the new well, and we get from them 245,000 gallons of water. Mr. Schlund has referred to the caulking of the faulty joints in reservoir with oakum. Those joints were cut down the whole depth of the brickwork, and there are two inches of cement covering the oakum. The headings were all dry when driven, the water being pumped down.

A **Member**: What is the size of the headings?

Mr. **Pritchard**: 6 feet by 4½. I cannot give you the cost of pumping, but I think it averages between 2*d.* and 3*d.* per thousand gallons. Of course the clay and cement joint at the bottom of the pipe was only temporary. One gentleman asked about the analysis of the water. Well, that is an analysis taken at the end of the summer. Analyses are taken pretty frequently, and all appear about the same in quality and hardness.

At the mid-day adjournment on Thursday, the President and Members of the Association were the Guests of the Right Worshipful the Mayor of Norwich (Mr. H. Z. T. Flowers) at luncheon at the Maid's Head Hotel. In the evening the Annual Association Dinner was held at the Maid's Head Hotel, the President (Mr. A. E. Collins) in the chair.

Immediately following the conclusion of the technical business of the Annual Meeting on the Friday, the President and Members proceeded in conveyances to the Heigham Works of the City of Norwich Water Company. Awaiting the party at the works were Alderman A. R. Chamberlain, Chairman, and the Directors of the Company, Mr. Charles Hawksley, Consulting Engineer of the Company, and Mr. W. H. Parr, Manager. The Mayor of Norwich was also present. The works of the Company were inspected, including the intake from the River Wensum, low-lift pumps, high-lift pumps, multiple pump valves of latter, sedimentation tanks, filters, sand washers, etc. The President and Members were afterwards entertained to luncheon by the Directors of the Water Company.

The party then proceeded to the Westwick depot of the Norwich Corporation. Here the Members went over the extensive and admirably planned depot, inspecting the stores, stables, workshops, and air-compressing station.

Visits were next paid to the Palace and Bishop's Bridge Gas Works of the British Gas Light Company. At the Palace Gas Works the President and Members were received and welcomed by Mr. Thomas Glover, Engineer and Manager of the Company, under whose guidance they inspected the modern gas making plant, including mechanically fed and discharged retorts, water gas plant, and coal and coke discharging, distributing, and storage plant. From the Palace Works the Members went to the Bishop's Bridge Works, where Mr. Glover had arranged a most complete and interesting exhibition of street lighting lanterns and fittings, together with Glover's arrangenent of distributing valves and new photometric apparatus. Light refreshments were served on the invitation of the Chairman (Mr. Horsley Palmer), the Directors, and Mr. T. Glover, the Engineer and Manager of the British Gas Light Company.

The round of visits was concluded by a visit to the Castle Museum and an inspection of the historical Regalia of the Corporation at the Guildhall.

In the evening, the Members were the Guests of the President at a most successful smoking concert held in the Blackfriars Hall.

Saturday was devoted to a most enjoyable excursion to Broadland. The Members travelled by train to Wroxham, where they went aboard electric and steam launches for a most enjoyable excursion on the far-famed Norfolk Broads, visiting the Wroxham and Salhouse Broads. The party was entertained to refreshments by the Sheriff (Mr. H. L. Clark) at his riverside bungalow, and had luncheon together at the Swan at Horning. Beautiful weather prevailed.

APPENDIX.

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CERTIFICATED CANDIDATES 448
MEMOIRS OF DECEASED MEMBERS.. 449

STATISTICAL RETURNS

On the following subjects lie at the Offices of the Association, 11 Victoria Street, Westminster, S.W. Those marked thus * are in duplicate, and can be borrowed for perusal by Members on application to the Secretary. Those *not* marked * can only be inspected at the Offices.

N.B.—Please Quote Reference Number.

(Members are requested, when sending statistics, to kindly send them in duplicate if possible.)

Ref. No.

Abattoirs (Public).

12 Compiled by W. Chapple Eddowes, Shrewsbury. 1902.

Cemeteries (Public).

53 *Compiled by H. Richardson, Handsworth. 1904.

Drainage Connections (Private).

11 *Compiled by H. Richardson, A.M. Inst. C.E. 1902.

Drainage (House).

1 Compiled by J. Atkinson, A.M. Inst. C.E., Stockport. 1894.

Drainage (New Buildings).

49 *Compiled by E. J. Lovegrove, M. Inst. C.E., Hornsey. 1896.

Fire Brigades.

36 Compiled by G. T. Lynam, A.M. Inst. C.E., Burton-on-Trent. 1899.

Horses (Cost of Keeping).

2 Compiled by M. Petree, A.M. Inst. C.E., Grimsby. 1896.

Hospital (Infectious Diseases).

59 *Compiled by J. Walker Smith, Barrow-in-Furness. 1905.

Ref. No.

LIGHTING (ELECTRIC).

3 Compiled by J. W. Brown, A.M. Inst. C.E., West Hartlepool. 1894.

4 Compiled by J. W. Cockrill, A.M. Inst. C.E., Great Yarmouth. 1891.

5 Compiled by W. A. Davies, A.M. Inst. C.E., Aston Manor. 1893.

40 Compiled by E. J. Silcock, A.M. Inst. C.E., King's Lynn. 1896.

LIGHTING (GAS).

6 Compiled by J. W. Bradley, A.M. Inst. C.E., Nelson. 1895.

7 Undertakings in the hands of Local Authorities. Compiled by P. Ross, A.M. Inst. C.E., North Bierley. 1896.

LIGHTING (PUBLIC STREET).

8 Compiled by A. H. Campbell, A.M. Inst. C.E., Canterbury. 1895.

9 Compiled by C. C. Smith, Dalton-in-Furness. 1892.

48 *Compiled by E. J. Lovegrove, M. Inst. C.E., Hornsey. 1900.

54 *Compiled by A. E. Nichols. 1903.

LIQUID NIGHT SOIL (DISPOSAL OF).

38 *Compiled by G. T. Lynam, A.M. Inst. C.E., Burton-on-Trent. 1899.

MOTOR WAGONS (UTILITY AND WORKING OF).

57 *Compiled by J. Walker Smith, Barrow-in-Furness. 1905.

58 *Compiled by R. J. Angel, A.M. Inst. C.E., Bermondsey. 1903.

PAVEMENTS (COMPARISON OF LIFE AND COST OF GRANITE AND GRITSTONE).

10 Compiled by C. F. Wike, M. Inst. C.E., Sheffield. 1890.

PAVEMENTS (TAR MACADAM).

46 Compiled by A. E. Collins, A.M. Inst. C.E., Norwich. 1896.

47 Compiled by J. Hall, M. Inst. C.E., Cheltenham. 1896.

41 Compiled by E. A. Stickland, A.M. Inst. C.E., Windsor. 1897.

Ref. No.

PRIVATE STREET IMPROVEMENTS (CONSTRUCTION OF WORKS OF).

13 Compiled by W. J. Newton, A.M. Inst. C.E., Accrington. 1892.

56 *Compiled by T. J. Rushbrooke, Chepping Wycombe. 1905.

PUBLIC BATHS AND WASHHOUSES.

42 *Compiled by P. Edinger, Frome. 1897.

55 *Compiled by J. Walker Smith, Barrow-in-Furness. 1905.

REFUSE (COLLECTION OF).

14 Compiled by J. Price, A.M. Inst. C.E., Toxteth Park. 1891.

REFUSE (DESTRUCTORS).

15 Compiled by W. Brooke, A.M. Inst. C.E., Richmond. 1885.

33 Compiled by J. Gammage, Borough Surveyor, Dudley. 1899.

REFUSE (DISPOSAL OF).

16 Compiled by J. Price, A.M. Inst. C.E., Toxteth Park. 1896.

REFUSE (REMOVAL OF).

17 Compiled by C. R. Fortune, Bath. 1886.

ROADS (MAINTENANCE OF MAIN IN NON-COUNTY BOROUGHS).

18 Compiled by W. Howard-Smith, A.M. Inst. C.E., Carlisle. 1894.

ROADS (PAVING OF MAIN).

31 Compiled by H. Richardson, A.M. Inst. C.E., Aston Manor. 1899.

ROADS (STEAM ROLLING OF).

19 Compiled by A. W. Parry, A.M. Inst. C.E., Reading.

ROADS (WATERING OF).

20 Compiled by W. Dawson, A.M. Inst. C.E., Leyton. 1891.

SCAVENGING (STREET).

17 Compiled by C. R. Fortune, Bath. 1886.

SEWAGE (DISPOSAL OF).

21 Compiled by J. H. Cox, M. Inst. C.E., Bradford. 1892.

22 Compiled by H. Richardson, A.M. Inst. C.E., Oldbury. 1890.

39 Compiled by J. W. Cockrill, M. Inst. C.E.. 1900.

Ref. No.

SEWAGE DISPOSAL WORKS.

35 *Compiled by G. T. Lynam, A.M. Inst. C.E., Burton-on-Trent. 1899.

SEWAGE (PURIFICATION OF).

22 Compiled by H. Richardson, A.M. Inst. C.E., Oldbury. 1890.

SEWERS (VENTILATION OF).

23 Compiled by J. T. Earnshaw, A.M. Inst. C.E., Ashton-under-Lyne. 1893.

51 *Compiled by H. G. Whyatt, Grimsby. 1900.

SLAUGHTER-HOUSES.

25 Compiled by J. W. Cockrill, A.M. Inst. C.E., Great Yarmouth. 1885.

STREETS (CONSTRUCTION OF NEW).

50 *Compiled by T. R. Smith, Kettering. 1902.

TEAM LABOUR.

52 *Compiled by T. J. Rushbrooke, Chepping Wycombe. 1904.

TRAMWAYS.

26 Compiled by J. E. Swindlehurst, A.M. Inst. C.E., Burton-on-Trent. 1891.

TRAMWAYS (ELECTRIC).

24 *Compiled by G. T. Lynam, A.M. Inst. C.E., Burton-on-Trent. 1903.

34 Compiled by the Town Clerk of Birmingham. 1899.

43 Compiled by Chas. Mayne, A.M. Inst. C.E., Municipal Engineer, Shanghai. 1897.

UNDERGROUND TELEPHONE AND TELEGRAPH WIRES.

37 *Compiled by G. T. Lynam, A.M. Inst. C.E., Burton-on-Trent. 1899.

WATER RATES.

44 Compiled by A. W. Lawson, A.M. Inst. C.E., Borough Engineer, Rawtenstall. 1898.

Ref. No.

WATER SUPPLY (DIAMETERS AND DEPTHS OF MAINS FROZEN IN 1895).

27 Compiled by E. Pritchard, M. Inst. C.E., Birmingham. 1895.

WATER SUPPLY (FOR DOMESTIC AND GENERAL PURPOSES).

28 Compiled by J. T. Eayrs, A.M. Inst. C.E., West Bromwich. 1890.

WORKMEN'S DWELLINGS.

29 *Compiled by J. W. Cockrill, A.M. Inst. C.E., Great Yarmouth. 1897.

WORKMEN'S WAGES AND HOURS OF LABOUR.

45 Compiled by J. R. Dixon, A.M. Inst. C.E., Shoreditch. 1897.

30 Compiled by R. H. Haynes, Newport, Mon. 1897.

32 Compiled by S. E. Burgess, M. Inst. C.E., South Shields. 1899.

TRANSACTIONS OF OTHER SOCIETIES, BOOKS, ETC.

London Chamber of Commerce. Report on Secret Commissions. 1899.

London Chamber of Commerce. Report on Cement Admixtures. 1897.

British Fire Prevention Committee.

Field Work and Instruments. By A. T. Walmisley.

Glasgow Engineering Congress, 1901.

Institution of Mechanical Engineers.

Land Surveying and Levelling. By A. T. Walmisley.

Society of Engineers.

Stresses and Strains. By F. R. Farrow.

Structural Iron and Steel. By W. N. Twelvetrees.

The Sanitary Institute.

SPECIAL REPORTS.

Bacterial Treatment of Sewage. Prof. Frank Clowes, D.Sc. (London), and A. C. Houston, M.B. D.Sc. 1904.

Bacteriological Experiments with Sewage. Borough Surveyor, Leicester. 1900.

British Standard Sections. Engineering Standards Committee. 1903.

Disposal of Refuse, etc., in Cities of Melbourne and Adelaide, Report on. City Surveyor, Sydney. 1891.

Manchester Main Drainage, Report on. City Surveyor, Manchester. 1896.

Public Baths, Instructions, etc. to Architects. Surveyor to the Urban District Council, Handsworth. 1901.

Refuse Destructor and Electricity Works, Report on. Borough Engineer, Nelson. 1899.

Sewage Disposal, Report on. Borough Surveyor, Bradford.

Sewage Disposal Works, Specification, etc. for. Borough Engineer, Blackburn.

Sewage Purification. J. D. Watson. 1903.

Sewer Ventilation, Report on. Borough Engineer, Leicester. 1899.

Steam Road Rolling, Report on. County Surveyor, Hereford. 1897.

Storage of Flood Water. Prof. H. Robinson. 1899.

Town Refuse Destructors, Report on. Borough Surveyor of Ipswich. 1896.

Tramway Traction, Report on.

—— City Surveyor, Birmingham. 1899.

—— City Surveyor, Sheffield. 1897.

Treatment and Destruction of Refuse, Report on. City Surveyor, Sydney. 1897.

Well Sinking and Boring Operations. Surveyor to the Urban District Council, Handsworth. 1904.

Western Australian Hard Woods. Agent-General for Western Australia. 1902.

PAMPHLETS.

Conical Projection of Maps. R. H. Foy. 1901.

Destructors and Steam Production. W. H. Maxwell. 1901.

Formulæ and Tables of Velocities and Discharges of Sewers. T. De Courcy Meade. 1897.

Greater Manchester. J. Swarbrick. 1903.

Hodograph, the. T. Ferguson. 1901.

Incrustation of Iron Water Pipes. Water Engineer, Torquay.

Meteorology of Nottingham. Also Chart showing the relation of the Number of Deaths from various causes to Meteorological Conditions for 1904. Compiled by A. Brown, M. Inst. C.E., Borough Surveyor, Nottingham, and Philip Boobbyer, M.B.

Presidential Address to Association of Birmingham Students. J. Price. 1902.

Raising of Water from Deep Wells by Compressed Air. W. H. Maxwell. 1903.

Type Drawings for Melbourne Sewerage. W. Thwaites, Chief Engineer, Melbourne.

Drawings of Lot's Road Pumping Station, L.C.C. Maurice Fitzmaurice, Chief Engineer.

JOURNALS.

American Electrician.
„ Electrical World and Engineer.
„ Engineering Record.
Builder.
Cassier's Magazine.
Contract Journal.
Electrical Engineer.
Engineering Times.
Local Government Chronicle.
Page's Magazine.
Public Health Engineer.
Sanitary Record.
Street Railway Journal.
Surveyor and Municipal and County Engineer.
The Quarry.
Water.

PAPERS.

A few prints of the following Papers (contained in past Volumes of 'Proceedings') are in stock at the Offices of the Association, and may be obtained from the Secretary, *if the* **Reference Number** *is quoted and an addressed postal wrapper is enclosed for each paper required.*

98 **Aberdeen, Municipal Engineering in.** W. Dyack.
97 **Aberdeen Waterworks.** J. Gordon.
22 **American Sewer Design.** J. S. Hodgson.
28 **Bristol Tramways Electrical Installation.** J. Clifton Robinson.
13 **Buxton Municipal Works.** W. H. Grieves.
90 **Chichester, Municipal Engineering Works in.** James Saunders.
86 **Coal-Mining Subsidences in Relation to Sewerage Works.** F. W. Mager.

29	**Electrical Works in Bristol.** H. Faraday Proctor.
96	**Electric Cable Subway.** G. R. G. Conway.
88	**Housing of the Labouring Classes.** A. H. Campbell.
110	**Housing of the Working Classes.** R. S. Rounthwaite.
15	**Isolation Hospitals.** F. Smythe.
1	**King's Lynn Municipal Works.** Henry James Weaver.
93	**Oswestry, Municipal Work in.** G. William Lacey.
94	**Passenger Lift, Water Balance.** P. H. Palmer.
3	**Purification Works at Minworth Greaves.** A. Bryan.
6	**Refuse Destructor.** D. J. Roberts.
21	**Reservoir Construction.** G. Mitchell.
100	**Runcorn, Municipal Work in.** J. Wilding.
4	**Sewage and Sludge Disposal.** G. A. Hart.
18	**Sewage Disposal.** A. Creer.
23	**Shone's Ventilation System.** E. G. Mawbey.
25	**Shrewsbury Main Drainage.** G. Midgley Taylor.
91	**Southend-on-Sea, The Municipal Works of.** Alfred Fidler.
104	**Sudbury, Municipal Work at.** T. W. A. Hayward.
89	**Swadlincote Public Works.** Thomas Kidd.
14	**Tramways, Wear and Maintenance of.** C. F. Wike.
105	**Ventilation of Drains.** C. C. Smith.
111	**Ventilation of Sewers.** A. W. Cross.
106	**Ventilation of Sewers.** H. H. Humphries.
112	**Ventilation of Sewers.** R. Read.
107	**Ventilation of Sewers.** W. J. Steele.
103	**Water Supplies.** R. Pickering.
102	**Whitehaven, Public Works of.** J. S. Brodie.
99	**Widnes Corporation Gas and Water Works.** J. Carr.
101	**Widnes, Municipal Works of.** J. S. Sinclair.
26	**Withington Municipal Works.** A. H. Mountain.

EXAMINATIONS.

SYLLABUS.

The Incorporated Association of Municipal and County Engineers undertake the holding of Examinations, by written papers and *vivâ voce*, in the four following subjects:—

Engineering as applied to Municipal work.
Building Construction and Materials.
Sanitary Science as applied to Towns and Buildings.
Municipal and Local Government Law as relating to the work of Municipal Engineers and Surveyors.

Every candidate who applies for permission to sit for the Examination of the Association must possess one of the Certificates hereinafter mentioned in each of the following subjects:—

English, including (1) English Composition; (2) English Grammar, including Analysis and Parsing; (3) English History; (4) Geography.

Mathematics, including (1) *Arithmetic*—Vulgar and decimal fractions, proportion, square root, simple and compound interest, profit and loss, percentage, H.C.F. and L.C.M.; (2) *Algebra*—the ordinary rules; fractions; brackets; simple, simultaneous and easy quadratic equations, and problems involving the use of such equations; H.C.F.; L.C.M.; and square root; (3) *Euclid*—the first three books.

List of Certificates which will be accepted as evidence that Candidates possess the necessary qualifications in the various subjects:—

(1) English Composition and (2) English Grammar.

University of London: Matriculation Examination.
Victoria University: Preliminary Examination.
University of St. Andrews: Preliminary Examination in Science.
University of Glasgow: Preliminary Examination in Science.
University of Aberdeen: Preliminary Examination in Science.
University of Edinburgh: Preliminary Examination in Science.
University of Dublin: General Examination at end of Senior Freshman year.

University of Wales: Matriculation Examination.

University of Birmingham: Matriculation Examination.

King's College, London: Examination for the College Matriculation Certificate in Engineering.

University College, London: Matriculation Examination (Engineering Department).

Royal Indian Engineering College, Cooper's Hill: Entrance Examination.

City and Guilds of London Central Technical College: Matriculation Examination.

University College, Bristol: Preliminary Examination (Engineering Department).

Scotch Education Department: The Leaving Certificate.

Oxford and Cambridge Schools Examination Board: A Higher Certificate.

University of Adelaide: Senior Public Examination.

University of Tasmania: Senior Public Examination.

Central Welsh Board: Honours, Senior or Junior. Certificate to be endorsed "English Composition," "English Language," and "English Literature."

Society of Arts: Advanced stage—First or Second Class, obtained since 1904; Intermediate stage—First Class, obtained since 1904; and the certificates corresponding thereto obtained prior to 1904.

College of Preceptors: First Class (or Senior), Second Class (or Junior), in the Professional Preliminary Examination; First Class (or Senior), Second Class (or Junior), in Certificate Examination.

Oxford Local:
    Senior Examination—Honours or Pass.
    Junior Examination—Honours or Pass.
Cambridge Local:
    Senior Examination—Honours or Pass.
    Junior Examination—Honours or Pass.

Certificate for English Language and Literature will be accepted as qualification required in English Composition and English Grammar.

(3) English History.

University of London: Matriculation Examination.

Victoria University: Preliminary Examination.

University of St. Andrews: Preliminary Examination in Science.

University of Glasgow: Preliminary Examination in Science.

University of Aberdeen: Preliminary Examination in Science.

University of Edinburgh: Preliminary Examination in Science.

University of Dublin: General Examination at end of Senior Freshman year.

University of Wales: Matriculation Examination.

University of Birmingham: Matriculation Examination.

King's College, London: Examination for the College Matriculation Certificate in Engineering.

University College, London: Matriculation Examination (Engineering Department).

Royal Indian Engineering College, Cooper's Hill: Entrance Examination.

City and Guilds of London Central Technical College: Matriculation Examination.

University College, Bristol: Preliminary Examination (Engineering Department).

Scotch Education Department: The Leaving Certificate.

Oxford and Cambridge Schools Examination Board: A Higher Certificate.

University of Adelaide: Senior Public Examination.
University of Tasmania: Senior Public Examination.
Central Welsh Board: Honours, Senior or Junior.
Society of Arts: As for English Composition and English Grammar. Certificate for Commercial History and Geography will be accepted a qualification required in English History and Geography.
College of Preceptors: As for English Composition and English Grammar.
Oxford Local: As for English Composition and English Grammar. Certificate for History will be accepted as qualification required in English History.
Cambridge Local: As for English Composition and English Grammar. Certificate (Senior or Junior) for History, Geography, etc., will be accepted as qualification required in English History and Geography.

(4) GEOGRAPHY.

University of London: Matriculation Examination.
Victoria University: Preliminary Examination.
University of St. Andrews: Preliminary Examination in Science.
University of Glasgow: Preliminary Examination in Science.
University of Aberdeen: Preliminary Examination in Science.
University of Edinburgh: Preliminary Examination in Science.
University of Dublin: General Examination at end of Senior Freshman year.
University of Wales: Matriculation Examination.
University of Birmingham: Matriculation Examination.
King's College, London: Examination for the College Matriculation Certificate in Engineering.
University College, London: Matriculation Examination (Engineering Department).
Royal Indian Engineering College, Cooper's Hill: Entrance Examination.
City and Guilds of London Central Technical College: Matriculation Examination.
University College, Bristol: Preliminary Examination (Engineering Department).
Scotch Education Department: The Leaving Certificate.
Oxford and Cambridge Schools Examination Board: A Higher Certificate.
University of Adelaide: Senior Public Examination.
University of Tasmania: Senior Public Examination.
Central Welsh Board: Honours, Senior or Junior.
Society of Arts: As for English History.
College of Preceptors: As for English Composition and English Grammar.
Oxford Local: As for English Composition and English Grammar.
Cambridge Local: As for English History.

MATHEMATICS.

University of London: Matriculation Examination.
Victoria University: Preliminary Examination.
University of St. Andrews: Preliminary Examination in Science.
University of Glasgow: Preliminary Examination in Science.
University of Aberdeen: Preliminary Examination in Science.
University of Edinburgh: Preliminary Examination in Science.
University of Dublin: General Examination at end of Senior Freshman year.

University of Wales: Matriculation Examination.

University of Birmingham: Matriculation Examination.

King's College, London: Examination for the College Matriculation Certificate in Engineering.

University College, London: Matriculation Examination (Engineering Department).

Royal Indian Engineering College, Cooper's Hill: Entrance Examination.

City and Guilds of London Central Technical College: Matriculation Examination.

University College, Bristol: Preliminary Examination (Engineering Department).

Scotch Education Department: The Leaving Certificate.

Oxford and Cambridge Schools Examination Board: A Higher Certificate.

University of Adelaide: Senior Public Examination.

University of Tasmania: Senior Public Examination.

Central Welsh Board: Honours, Senior or Junior. Certificate to be endorsed "Arithmetic," "Algebra," and "Geometry."

College of Preceptors: As for English Composition and English Grammar. Certificate to be endorsed "Arithmetic," "Algebra," and "Geometry."

Oxford Local: As for English Composition and English Grammar. Certificate to be endorsed "Arithmetic" and "Mathematics."

Cambridge Local: As for English Composition and English Grammar. Certificate to be endorsed "Arithmetic" and "Mathematics."

Board of Education: Science Examination—Stage 1, First Class; or Stages 2 and 3, any Class.

The foregoing regulations do not apply to Candidates who have previously sat or received permission to sit.

A Candidate who does not possess the requisite Certificates may be permitted to sit for the Examination of the Association prior to November 1, 1906, provided he has been articled or is an assistant to an engineer to an urban, a county borough, or rural district council, and produces satisfactory Certificates from the master under whom he studied the subjects required. Such Certificates to be made out on the Form supplied by the Association. No Certificate will be accepted from a master who is not a Graduate of a British or Colonial University, or who does not possess a degree equivalent thereto, or who is not a certificated teacher.

A Candidate who has been awarded any of the undermentioned Certificates is exempt from further educational examination: The Institution of Civil Engineers, Studentship; The Royal Institute of British Architects, Preliminary; the Surveyors' Institution, Preliminary.

The Council reserve power to alter or add to the foregoing requirements.

Two or more Examinations are held in each year, one at least, in April, in London, and one at least, in October, in some provincial town to be fixed on by the Council and duly advertised beforehand.

Examinations will also be held in Scotland and Ireland, providing a sufficient number of Candidates desire to enter. Examinations in Scotland will be held in October; in Ireland, in April.

The Council will consider applications, and, if desirable, grant permission, to sit at these Examinations.

Intending candidates who have not previously applied for permission to sit, must do so on the form issued with the syllabus.

If permission is granted by the Council, a "sitting" form will be forwarded. The candidate may then make application on such form to be entered for the next ensuing, or any future, examination.

The Council will accept entries, in order of priority, as far as accommodation will permit.

Candidates who have sat and failed, or who have applied for and received permission to sit, are particularly requested to ask for a "sitting" form, when they desire to enter their names for examination.

The fee is to be sent with the sitting form ONLY.

Candidates must have attained their twenty-second birthday.

The fee for each Examination is 4*l.* 4*s.*, two guineas to be paid with the "sitting" form, and the balance on the day of examination. Should the candidate fail, he is entitled to present himself at any subsequent Examination, on payment of 2*l.* 2*s.*, one guinea to be paid on application and one guinea on the day of Examination.

Candidates who sat and failed at any of the Examinations held prior to and including April 1898, pay 1*l.* 1*s.* entrance, and 10*s.* 6*d.* sitting fees.

No further charge is made to the candidate than the fees above mentioned.

Candidates who do not present themselves for examination forfeit their entrance fee.

Candidates are not necessarily required to answer all the questions set in each paper: marks are given for all questions correctly answered. Where the subject is sub-divided, at least one question should be attempted in each sub-section.

The Examinations occupy three days, and the arrangements are as follows:—

First day,	10 to 1	Sanitary Science.
„	2.30 to 6.30 ..	Building Construction.
Second day,	10 to 1	Engineering (1st Paper).
„	2.30 to 6 ..	„ (2nd „).
Third day,	9.30 to 11.30 ..	Municipal and Local Government Law.
„	12	*Vivâ voce* Examination.

Fifty per cent. of the total number of marks given are required to constitute a pass.

Successful candidates receive a Certificate in the form of a

"Testamur," signed by the acting Examiners, and sealed and countersigned by the President and Secretary of the Association in Council.

No information as to the result of an Examination, beyond the fact of a candidate having "Passed" or "Failed," is given.

Questions set at Examinations held prior to 1902 can only be obtained in the volumes of the 'Proceedings.' On sale by Messrs. E. & F. N. Spon, Ltd., Publishers, 57 Haymarket, S.W. The questions set at subsequent examinations are not published.

No exemption from any portion of the Examination is granted to candidates.

Any inquiries referring to the Examinations should be directed to Mr. Thomas Cole, Secretary to the Association, 11 Victoria Street, London, S.W., and should be accompanied by an addressed foolscap envelope.

SUBJECTS OF EXAMINATION.

I.—Engineering as applied to Municipal Work:

1st Paper.—A. Sewage Disposal.
B. Tramways Construction.
C. Bridge Construction.
D. Water Supply.

Questions in TWO at least of these subjects must be attempted.

2nd Paper.—A. Geodesy.
B. Hydraulics.
C. Sewerage.
D. Road Construction and Maintenance.

II.—Building Construction: Strength of Materials:

A. Materials.
B. The Construction of Public and Private Buildings.
C. Building By-laws.
D. Public Baths and Hospitals.

III.—Sanitary Science as applied to Towns and Buildings:

A. Heating and Ventilation.
B. Scavenging and Disposal of Refuse.
C. Water Supply and Drainage of Buildings.
D. Disinfection.

IV.—Municipal and Local Government Law as relating to the Work of Municipal Engineers and Surveyors.

Note.—The Examiners do not recommend any particular text-books, as it is desired to make the Examinations rather a test of the candidate's practical knowledge of the subjects generally, than to find his acquaintance with any particular book or books.

EXAMPLES OF QUESTIONS.

The following questions have been compiled from Examination Papers set to Candidates, and serve as examples of the questions asked under the different sections.

Directions.—"You are particularly requested to write legibly, and to answer the questions as concisely as possible. *Fill in your number where indicated, also at the top of every book handed in. Place this question-paper inside your book before handing it in. Prefix the number of the question to each answer. Where the subject is sub-divided, at least one question should be attempted in each sub-section.* Wherever possible, freehand sketches or diagrams should be drawn to illustrate the answer; these should be carefully executed, as they will be taken as showing the Candidate's proficiency in this style of drawing. Candidates must not, during the examination, refer to any books or manuscript, or communicate with each other. Slide rules may not be used."

Subject:—ENGINEERING as Applied to Municipal Work.

FIRST PAPER.

Sewage Disposal.

1. A residential town of 10,000 inhabitants, with an adequate water supply, has to be sewered and drained on to a square piece of land, 23 acres in extent, through the centre of which runs a stream, the land rising therefrom at a gradient of 1 in 50 on one side, and 1 in 130 on the other. The soil is loam, of an average depth of 2 ft. 6 in., on a substratum of friable clay. Two-thirds of the sewage can gravitate to the uppermost portion of land, the remainder is below bed of stream. Describe and illustrate by sketches the system of disposal you would recommend under these circumstances, giving particulars of construction, capacity, cost, quantity of sewage to be dealt with, (*a*) if storm-water included, (*b*) if excluded; also state standard of purity of effluent you consider satisfactory.

2. Describe one or more forms of aerating beds or filters for sewage purification, together with the arrangements for distributing the sewage thereon. State the object of such beds or filters, and the points in favour of the method of distribution you prefer, as compared with any other method known to you.

TRAMWAYS CONSTRUCTION.

3. Make a sketch of the cross section of a tramway worked on the overhead system, double track, standard gauge, on a 50-ft. road, and briefly describe the mode of construction of the permanent way.

4. (*a*) Sketch a section of a tram rail for electric traction with heavy traffic, giving dimensions in detail and weight per yard, and state the chief points to be observed in its chemical composition.
   (*b*) Similarly sketch a joint.
   (*c*) State the advantages and disadvantages (if any) of such a joint.

BRIDGE CONSTRUCTION.

5. Show a method of connecting a cross girder of a steel road bridge to the bottom boom of main girder, and of floor construction for the bridge. The bridge is 40 feet wide between main girders which form the parapets. Cross girders at 10 ft. centres. Total of dead and live loads, which may be taken as equally divided, 3 cwt. per superficial foot of floor surface. Candidate may select type of main and cross girders, and floor construction.

6. (*a*) Give the points to be considered in designing a steel girder road bridge of 100 ft. span and 42 ft. clear width between the main girders.
   (*b*) Briefly state the tests you would apply to the various parts of the bridge.

WATER SUPPLY.

7. An open reservoir, 20 ft. deep, has to be constructed on the side of a hill having a slope of 1 in 25, the foundation being large boulders and loose shale under 3 ft. of peaty soil. 180 days' storage has to be provided for a residential town of 20,000 inhabitants. Sketch and figure section through lower and upper sides and floor, and indicate the different materials used. Give cubical contents in feet and gallons, and the pressure per square foot on centre of floor and half-way up the side, when the reservoir is three-fourths full.

8. Describe and illustrate an apparatus by means of which a water main whilst remaining under pressure, may be drilled, tapped, and a service ferrule connected.

SECOND PAPER.

GEODESY.

1. It is proposed to purchase for a recreation ground, a four-sided field, 672 ft., 393 ft., 806 ft., and 297 ft., measured to centre of hedges, the ditch being inside in each case. Near the centre is a small irregularly-shaped orchard, about 90 poles in area, surrounded by an impenetrable hedge. Show by sketch plan your plotting out, give area, and cost at 300*l*. per acre.

2. State how you would test a level for parallax, and adjust it; and the method of testing and correcting for collimation.

HYDRAULICS.

3. What is the discharge of a water main 6 in. diameter, 2000 ft. long, with a fall of 15 feet?
4. What would be the quantity of water per minute which would run over a rectangular notch 1 ft. wide, and 1 ft. in depth from the water's surface, and show the calculations by which you arrive at the result?

SEWERAGE.

5. Sketch cross section of an egg-shaped sewer 5 ft. high, to be constructed through water-logged ground, giving diameters at top and bottom, radius of sides, and area. Indicate materials used, figure thicknesses, and write brief specification, including method of testing to be adopted. Give quantity of sewage discharged, if running 2 ft. 7 in. deep, with a velocity of 2 ft. per second.

6. You have a main outfall sewer with a 1 per cent. fall, and wish to connect a branch sewer from a higher district, the valley sides being so steep that you must have a 5 per cent. fall. How would you propose to reduce the velocity in the branch so that in heavy floods the main sewer would not be choked or blown up?

ROAD CONSTRUCTION AND MAINTENANCE.

7. A road 20 ft. wide, a mile long, having but little waste at sides, with a very slight fall from either end to near the centre, where is the only outlet for storm-water, has been destroyed by heavy traffic, there being no foundation other than coarse sand and gravel 18 inches deep, over stiff clay. Describe, by short specification and sketches, how you would proceed to thoroughly re-instate and drain the road, using the prices of the various materials and labour prevalent in your own neighbourhood; and give the quantities required, and estimate cost of work.

8. What are the advantages and disadvantages respectively of maintaining macadamised roads by the system of continuous coatings, as compared with the system of systematic patching?

SUBJECT :—BUILDING CONSTRUCTION.

A. MATERIALS.

1. What descriptions of timber are best suited for the construction of outside work? Name them in order of merit.

2. Write a specification of good hair mortar.

3. Give the proper thicknesses of sheet lead in lbs. per square foot used on roofs in various parts, giving the trade terms.

B. THE CONSTRUCTION OF PUBLIC AND PRIVATE BUILDINGS.

1. What is meant by a "king post" and a "queen post" principal? Make a sketch of each, with scantlings, applied to spans of 25 feet and 50 feet respectively, and state distances between the principals.

2. What proportions of cement, sand and broken brick or stone would you specify for concrete for
   (*a*) Foundations for main walls.
   (*b*) Concrete stair landings.
   (*c*) Water-tight work.

3. Draw a figured section of a wrought-iron girder over a shop, 20 feet clear span, to carry front wall of house, two stories, 23 feet total height, and the floor joists of two rooms, the thickness of the wall to be 1½ brick.

C. BUILDING BY-LAWS.

1. State the means of ventilation required to be provided for a "habitable room without a fire-place."

2. What proportion do the "Model By-Laws" prescribe for the open space in rear of a dwelling, and how to be measured?

3. State generally the requirements of these by-laws as to—
   (*a*) The levels, widths and construction of new streets.
   (*b*) The construction of water-closets in a building.

D. PUBLIC BATHS AND HOSPITALS.

1. Give sketches and descriptions of a covered swimming-bath pond, and of the heating and overflow arrangements thereof.

2. In case of a temporary hospital for immediate requirements, give sketch plan showing position of closets, bath, nurses' room and administrative departments.

SUBJECT:—SANITARY SCIENCE AS APPLIED TO TOWNS AND BUILDINGS.

A. HEATING AND VENTILATION.

1. How would you warm and ventilate a ward in an infectious diseases hospital?
2. Describe various methods of ventilating sewers, and give opinions as to the merits or otherwise of the same.
3. Describe the system you would employ for ventilating a theatre of average size, assuming your own conditions.

B. SCAVENGING AND DISPOSAL OF REFUSE.

1. Describe, so far as house refuse is concerned, the best mode of collection.
2. How many cells would you specify in a refuse destructor for a population of 40,000 in a residential town?
3. Give a short description of the "conservancy" systems of disposal of town's refuse, and the advantages or disadvantages of each system.

C. WATER SUPPLY AND DRAINAGE OF BUILDINGS.

1. State the advantages of soft water and of hard, comparatively.
2. A dwelling house is to be erected on damp subsoil; describe in detail the necessary works to render it dry and healthy.
3. What gradient would be necessary in 4, 6 and 9-inch pipe to ensure self-cleansing?

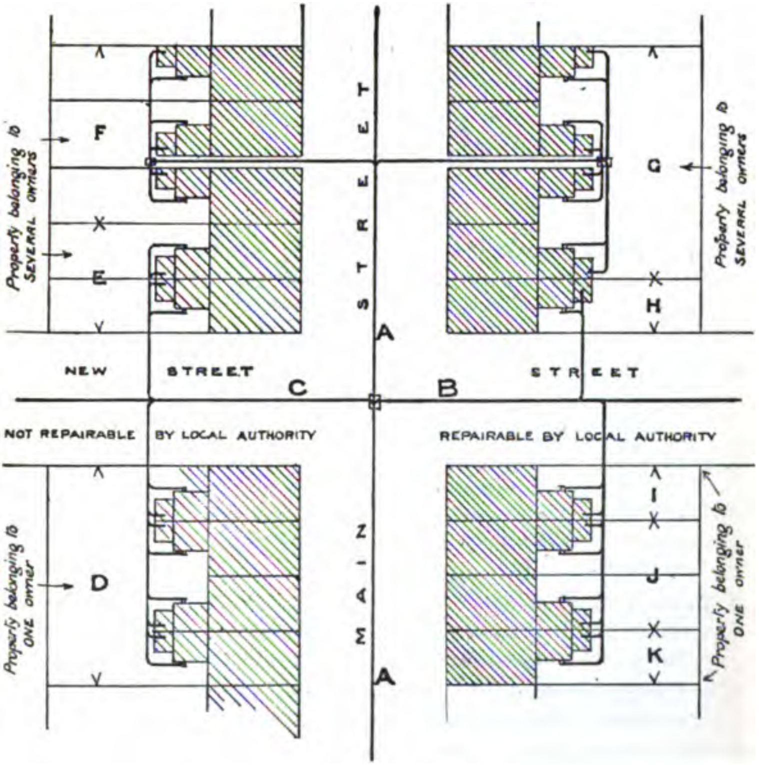
D. DISINFECTION.

1. Describe a disinfecting station suitable for a town of 40,000 population, noticing the special points, and giving the principal dimensions. Give an approximate estimate of cost excluding land, stating cost of 9-inch brickwork per square yard.
2. Describe various forms of disinfecting apparatus.
3. What method would you adopt to prevent the spread of infectious disease which has broken out in a crowded portion of the district?

SUBJECT:—MUNICIPAL AND LOCAL GOVERNMENT LAW AS RELATING TO THE WORK OF MUNICIPAL AND COUNTY ENGINEERS AND SURVEYORS.

(England)

1. Mark on the accompanying plan which are "sewers" and which are "drains" in connection with the streets A, B and C, and the properties D to K respectively, giving the grounds upon which you base your conclusions.


Property belonging to SEVERAL OWNERS
F
X
E
STREET
G
Property belonging to SEVERAL OWNERS
X
H
A
NEW STREET
C
B
STREET
NOT REPAIRABLE BY LOCAL AUTHORITY
REPAIRABLE BY LOCAL AUTHORITY
Property belonging to ONE OWNER
D
MAIN
I
X
J
X
K
Property belonging to ONE OWNER
A

2. State the provisions of the Public Health Acts Amendment Act, 1890, with respect to "Sanitary Conveniences for manufactories." What number of water-closets should you consider sufficient for (*a*) 100 males; (*b*) 100 females?

3. Specify the duty of a local authority with respect to (*a*) nuisances; (*b*) epidemics.

4. Give a short outline of Act for Housing of the Working Classes, and the responsibility of a local authority where the same has been adopted.

5. An urban authority desires to widen and improve a public street. State the different methods of proceeding. Name the various Acts and clauses.

6. What are the regulations prescribed in the Tramways Act, 1870, with regard to opening, breaking up and altering the level of roads by a tramway company for the purpose of making, maintaining and renewing a duly authorised tramway?

7. What is the meaning of the term "main road," used in the Local Government (England and Wales) Act, 1888, and in the Highways and Locomotives (Amendment) Act, 1878?

8. What steps must a local authority take before commencing sewerage or sewage works without their district?

9. In what manner, and under what Act, may ruinous or dangerous buildings be dealt with?

MUNICIPAL AND LOCAL GOVERNMENT LAW AS RELATING TO THE WORK OF MUNICIPAL ENGINEERS AND SURVEYORS.

(Scotland)

1. Define the various roads to which these words apply, viz., Highway, Turnpike Road, Statute Labour Road, as interpreted by the Roads and Bridges (Scotland) Act, 1878.

2. Describe the statutory provisions whereby a local authority can recover from any person expenses for damage to highways caused by extraordinary traffic thereon, or by excessive weight passing along the same; and state in what Act of Parliament these provisions are embraced.

3. To whom must application be made for authority to lay out new streets? Specify the details which require to be shown on the plan accompanying the application.

4. If a Burgh should desire to improve any existing private streets, what statutory procedure would be necessary?

5. What are the powers of a Burgh with reference to the keeping of footpaths of public streets in proper repair? How far do these powers apply to private streets?

6. Specify the procedure which must be adopted in a Police Burgh before a public sewer can be laid. Under what Act is this necessary?

7. What powers of entry are given under the Public Health (Scotland) Act for the purpose of examining drains, and what is the necessary procedure?

8. Specify the duty of a Local Authority with reference to the water supply of buildings in an isolated district.

9. Enumerate the powers given for the formation of special water supply districts. State briefly under what circumstances a Local Authority is bound to take action.

10. What were the requirements of the 1892 Burgh Police (Scotland) Act with regard to back space for proposed buildings, and what alteration was made by the 1903 Act?

BOARD OF EXAMINERS.

The President of the Association (*ex-officio*).

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CANDIDATES WHO PASSED THE EXAMINATION HELD 1904–1905.

46th and 47th Examinations, October 1904.

C. G. Bradley.
E. M. Bull.
A. B. Cathcart.
R. E. Clarke.
F. Crook.
A. E. Darby.
W. J. Goode.
A. T. Gooseman.
A. Grove.
J. R. Hadfield.
H. W. Hague.
H. F. Hutchinson.
L. Kenyon.
H. B. Mathew.
J. E. Needham.
J. Owen.
C. Pursey.
J. J. Quirk.
J. H. Woolston-Smith.
W. Wright.

48th and 49th Examinations, April 1905.

H. W. Barker.
R. Butler.
W. G. Cross.
W. Farrar.
F. G. Greenhill.
E. Gunson.
B. Halstead.
J. Hassall.
J. A. Jones.
G. H. Kay.
A. J. Lyddon.
A. J. McArd.
F. E. Marsh.
S. Matthew.
E. Minors.
G. L. Morgan.
J. Nighy.
J. Norrington.
E. Parry.
D. H. Price.
B. Royce.
J. H. Sagar.
J. A. Tonge.

Memoirs of Deceased Members.

The Council having been requested to append some short notice of the decease of Members of this Association, will feel obliged by early notice being forwarded to the Secretary, with such particulars as it may be desirable to insert in these 'Proceedings.'

Mr. **William Beatson**, late Burgh Surveyor, Leith, died on April 24, 1904, in his 72nd year. He was born at Abernethy, and received his early training in the employment of his father and his uncle. Later on he obtained a situation in the office of the City Architect of Glasgow, and was afterwards appointed Sanitary Inspector and Surveyor of Drainage at Paisley. In 1869 he was appointed Burgh Surveyor of Leith, and he held this office till 1902 when the post was made a joint one by the appointment of Mr. J. R. Findlay, of Montrose. He was elected a Member in September 1891.

Mr. **Edward Rice Sweet Escott**, formerly Borough Engineer of Halifax, died very suddenly of heart disease on September 8, 1904, in his 64th year. He went to Halifax as a young man as assistant to Mr. Boddy, the then Borough Engineer. Afterwards he was appointed Borough Surveyor of Burnley. On the death of Mr. Boddy in 1874, he was appointed his successor at Halifax, and held the office till 1899 when his health gave way and he was compelled to relinquish the position. He afterwards carried on for some time a practice as Consulting Engineer. He was one of the founders of the Association in 1873, and was President, 1895–96.

Mr. **Arthur John Leopold Evans**, late Borough Surveyor, Luton, died on December 13, 1904, of valvular disease of the heart, in his 41st year. He was born at Burslem and educated